Double the Number: High School Crowding and Schooling Outcomes

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Abstract

Cohort size, beyond its effect on class or school size, could have important implications for schooling outcomes and therefore, influence behavior. This paper shows the impact of an increased high school graduating cohort size on performance and collegiate attainment by examining reforms in Ghana that changed high school duration between 2007 and 2010. Using data on all high school graduates and application data from a large public university, I combine a cohort analysis and a regression discontinuity design leveraging a compulsory schooling law to isolate causal effects. I find notable changes in performance at the end of high school and the direction of change depends on high school duration. Graduates are less likely to obtain a college degree because they delay applying to college, and even when they do, colleges face supply constraints and cannot absorb the increased total demand. Students also respond by reducing selectivity in their application's field preferences. Outcomes for females and economically vulnerable students are not significantly different.

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I Introduction

A student's cohort size could have important implications for her outcomes and therefore influence her behavior. A large cohort size may imply a larger class or school size, and a possible increase in aggregate college demand or labor supply for high school graduates. Analyses of its effect typically rely on variation in birth cohorts over long periods and contend with the challenge of disentangling the cohort size effect from other unobserved trends (Hoxby (2000); Korenman and Neumark (2000); Card and Lemieux (2001a); Bound and Turner (2007)). For labor market outcomes, economists have overcome this challenge by considering shocks to high school graduating cohort size or labor demand shocks such as recessions or pandemics that change cohort size relative to labor demand (Morin (2015); Von Wachter (2020)). However, this challenge remains for education outcomes. Despite these studies that consider shocks to high school graduating cohort size, little evidence exists on human capital formation at the end of high school or higher education outcomes.

An increase in high school graduating cohort size may affect human capital formation if students' accumulated knowledge and collegiate attainment change. Fewer school resources per student and changes in student effort are possible mechanisms through which this cohort size can affect knowledge accumulation. Fewer resources may cause a decline in short-term performance but the direction of the effort change is ambiguous. In addition, if the source of the variation changes the cohort composition, schools may differential allocate resources by student type because of scarcity and these types may also have varied effort responses. The net effect is thus uncertain. On the college education market, a bigger high school graduating cohort may signal a fall in admission probability through increased college demand if there is no expected commensurate increase in supply. In response, students may change their application strategy on the extensive and intensive margin depending on their revised admission probability estimate.

In this paper, I exploit the unintended effect of two nationwide reforms in Ghana that created a dramatic quasi-random increase in high school graduating cohort size and estimate its effect on performance at the end of high school and college application decisions and outcomes. The first reform added a year to the duration of high school; increasing it from three to four years without changing the curriculum. Three years after this reform was implemented, the fourth year was removed by a second reform, again maintaining the curriculum. The removal of the fourth year caused a sharp increase in the 2013 graduating cohort size as two cohorts, the last cohort with four years and the first with three, graduated concurrently. From this point, I refer to these two cohorts as the double cohort, to students in the first reform with four years duration as students in the four-year reform and those affected by the removal of the extra year with only three, as students in the three-year reform.

I begin my analyses by examining time-series variation in a cohort analysis and compare high school students in the double cohort with those in single cohorts with the same duration. The first outcome of interest is a composite score from a national examination[1] at the end of high school, which certifies graduation and is also the main college admission criterion. This score captures the short-term effect of an increased graduating cohort size on performance. The college education market in Ghana is decentralized, similar to the United States and many other countries, but public universities make up over 50% of all tertiary admissions. I match high school graduates to applicant data from the University of Ghana, a large, public, and prestigious university, which accounts for at least 20% of these admissions for college-related outcomes. Here, I first consider the likelihood of a student applying to college immediately after high school and up to two years later and then examine the selectivity of their field choice and admission chances. Undergraduate applications are typically field-specific, thus, applicants specify a limited number of field choices.

One concern of the cohort analysis is that potential outcomes of students in single cohorts differ systematically from those in the double cohort due to unobserved cohort differences. For a stronger causal case, I leverage a compulsory elementary school start law in Ghana that requires schooling to begin in the calendar year a child turns six and implement a regression discontinuity

[1]This examination, known as the West African Senior Secondary Certificate Examinations, is also sub-regional as Anglophone countries in the Economic Community of West African States (ECOWAS) partake in it.

(RD) design. This law generates sharp discontinuities in students' high school graduating cohort on January first. I can thus back out the relevant cutoff year and compare marginal students on one side of the cutoff who are more likely to graduate in the double cohort with those on the other side who are not but have the same high school duration. In spite of random birth assignment around the cutoff, students born on or after January 1 are relatively older in their cohorts mechanically. If relative age is a determinant of my outcomes, results will be biased. To address this, I augment my analysis with a control cutoff with minimal discontinuity in the likelihood of graduating in the double cohort and employ a difference-in-regression discontinuity (D-RD) design to disentangle the effect of graduating in an increased cohort size and relative age effect and any such confounding factors.

I make three main points. First, the sharp increase in the graduating cohort size impacts short-term performance on the high school terminal examination and depends on high school duration. Secondly, college-bound students delay entry into the college education market and reduce the selectivity of their program choices conditional on applying. Lastly, strong supply-side barriers prevent colleges from absorbing the significant demand shock. Females and students more likely to be economically vulnerable are not differentially affected in all cases.

Expanding on the first point above, recall that the double cohort is composed of students in both the four and three-year reforms. I show that for those in the four-year reform, their high school performance falls by 19% standard deviation. In contrast, the performance of those in the three-year reform increases. This puzzle suggests mechanisms that interact differently with high school duration. The combined role of limited school resources due to congestion in the graduating cohort and increased effort by the students with fewer years could reconcile this. Two cohorts graduating simultaneously does not change the overall school size but leads to crowding in the graduating cohort. Lavy (2015) suggests schools in developing countries are likely to be burdened by resource constraints, and anecdotal evidence points to high schools allocating more resources to the graduating cohort in preparation for the terminal examination. This would imply fewer resources per student in their final year, leading to a fall in performance. Now, the double cohort also changes the composition of the graduating cohort, with students with three and four years preparing to write the same terminal examination. Schools may thus allocate more resources to their students with fewer years to compensate for the missing year. In this case, the negative impact of fewer resources will be predominantly for the four-year students. In addition, students with fewer years may also exert more effort if they feel disadvantaged competing with those with the extra year so that they do even better than their counterparts in the single cohorts.

My second set of findings on students' decisions on the college education market shows that students are at least 26% less likely to apply immediately after graduating high school, and this persists even two years after graduation. The persistence suggests students are not only postponing college but are forgoing it altogether. This finding corroborates de Roux and Riehl (2022), who show that academic breaks after high school caused students to forgo college. Students also reduce the selectivity of their first-choice programs. Lastly, my third set of findings on admission chances highlights severe supply inelasticity for colleges. Admission chances fall by at least 41%, and there is no evidence that colleges are willing or able to absorb the temporary demand shock.

This research contributes to three strands of literature. First I show that graduating cohort size impacts student performance without a significant change in overall school size. Many papers consider birth cohorts as a source of variation in class, entering cohort, or school size (Hoxby (2000); Angrist and Keueger (1991); Kuziemko (2006); Babcock et al. (2012); McMullen and Rouse (2012)). These tend to ignore that variation in birth cohorts also implies that class, entering cohort, and school size change in tandem. If the only effect of school size on performance is through cohort size and then class size, this distinction may be ignored. For elementary school outcomes, where these papers usually focus, this assumption may be plausible, however, at higher levels of schooling where many inputs are shared beyond class bounds, for example, subject teachers for multiple classes in the same cohort, this distinction becomes even more critical. This is the first paper to estimate the direct effect of a large graduating cohort on short-term performance with relatively no change in school size.

Also, in this literature, students in larger classes, schools, and entering cohorts usually experience these consistently throughout their schooling (Hoxby (2000)). In developing countries, this is even more likely because of resource scarcity in expanding the number of classrooms or schools to match population growth. Coupling this with the fact that the size effect persists over time (Krueger (1999)) suggests even when effects of size are measured in elementary school, students are likely to have had the chance to adjust to being in a larger size and the measured effect may an accumulated effect. This study shows that short-term performance is impacted even when cohort size changes suddenly, with uncertainty about its persistence.

My second contribution is to illustrate the effect of large-scale reforms that cause double cohorts on performance and college attainment. A small set of papers have examined the effect of graduating in a double cohort on college enrollment and labor market outcomes for smaller-scaled reforms for high school graduates in Ontario Canada and Germany (Morin (2015); Marcus and Zambre (2019)). I add to this literature and show that the double cohort impacts performance at the end of high school and college application behavior. Furthermore, these papers are set in developed countries where education inputs and the ability of education supply to respond to such shocks are not the same.

My third contribution shows that students may perceive an increase in cohort size as an increase in competition when making college decisions. The mechanisms proposed by some papers on how increased cohort size affects college attainment is first through students caring about reduced resources per student and thus reducing college enrollment (Bound and Turner (2007)) and perfect foresight of lower labor market returns from increased labor supply, which may make it better to forgo college and enter the market earlier (Card and Lemieux (2001b)). I show that another mechanism through which an increased cohort size can affect college decisions is by a perceived increase in competition where they respond by reducing the selectivity of their programs and possibly postponing college. Gonzalez (2015) shows that the former is a response to an explicit increase in competition resulting from affirmative action.

II Setting

Pre-tertiary education in Ghana begins with six years of elementary school and officially starts in the calendar year an individual turns six. This is followed by three years each in middle and high school, with nationwide terminal examinations marking both. This structure has undergone significant changes since 1961[2] and in this paper, I study the unintended effect of two reforms that changed the duration of high school without a change in the curriculum. The first reform changed it from three to four years, and after three years of implementation, a second removed the fourth year, resulting in two high school cohorts graduating at the same time in 2013. These changes create a natural experiment to study the effect of increased high school graduating cohort size on short-term performance and the subsequent effect on students' decisions and admission chances in a decentralized college system. Figure 1 summarizes the changes due to the reforms under consideration.

II.1 Pre-Tertiary Education Structure in Ghana

Pre-tertiary education officially begins the calendar year a child turns six, and this is a key ingredient for my empirical strategy. Over the past 35 years, this structure has been divided into elementary, middle school, and high school[3] but the total number of years has changed (Akyeampong et al. (2010)).

The requirement to start school in the calendar year a child turns six implies that from December 31st to January 1st of each year, I expect a discontinuous change in the school cohort

[2] Akyeampong et al. (2010) discusses comprehensively the evolution of education expansion and access since Ghana gained independence.

[3] The names of these divisions of the pre-tertiary structure have changed over the period. They are currently labeled primary, junior high school, and senior high school.

a child belongs to. Compulsory school start laws are common in many developed and developing countries. In developed countries like Norway, the compliance rate is high at 95% on average with rigorous methods for enforcement (Black et al. (2011)). In Ghana, however, the compliance rate is less than 50%. Furthermore, progression from one grade to the next is not smooth, with instances of grade skipping and repeating (LeClercq et al. (2017)). These features characterizing this setting have implications for my empirical strategy, and I discuss them in detail in section IV.

At the end of middle school, all students take a national examination known as the Basic Education Certificate Examination. The results serve as certification of completion and the main criterion for centralized assignment to high schools, which are typically different from middle schools[4] (Ajayi and Sidibe (2020)). Like middle schools, all students at the end of high school also participate in a nationwide examination which serves as certification of completion and the main criterion for applying to college in a decentralized system. Administrative data for these examinations form part of my data sources.

II.2 Reforms Resulting in Increased Cohort Size

For cohorts beginning high school in September 2007, high school duration was increased from three to four years. After it was implemented for three years, a second reform removed the extra year, and the duration reverted to three. The first cohort affected by the second reform started high school in 2010, and two cohorts graduated high school at the same time in 2013. I refer to this larger graduating cohort as the double cohort. In both reforms, the high school curriculum and the duration for elementary and middle schools remained unchanged.

The four-year reform was officially announced to increase the duration in January 2007 for the cohort beginning in September of that same year. This implied that the pre-tertiary structure changed from 6-3-3 to 6-3-4. The intended purpose of the four-year reform was to allow high

[4] Ajayi and Sidibe (2020) discuss the application and assignment process of middle school graduates to high school in this centralized system extensively.

schools more time to cover the same curriculum and improve performance. After a change of government in 2008, a three-year reform was officially announced in September 2009 to remove the fourth year of high school, reverting to 6-3-3, again with no curriculum changes. The first affected cohort entered high school in 2010. During this period, high school education was not free, and the stated reason for the reversion was the financial cost of the additional year for families.

These two reforms resulted in two high school cohorts graduating concurrently in 2013. They were the last cohort from the four-year reform, which entered in 2009, and the first cohort from the three-year, which entered in 2010. All students in the double cohort participated in the same terminal examination irrespective of their duration in high school, and there was no distinction during the examination and grading. Compression of high school duration is not unique to Ghana. In 1997, Ontario, Canada, announced the removal of the 13th grade, and a similar reform was also implemented in Germany between 2007 to 2016 (Morin (2015); Marcus and Zambre (2019)).

II.3 High School Examination and Decentralized College Market

The nationwide examination students take at the end of high school is known as the West African Senior School Certificate Examination (WASSCE). This examination is also sub-region-wide as Anglophone countries in ECOWAS partake in it[5]. Results from this examination serve as certification of completion, and for college-bound students in Ghana, it is typically the main criterion for applying to college. The examination covers seven or eight main subjects - four core subjects common to all and three or four elective subjects, which vary based on the student's area of specialization[6]. The sub-region-wide nature of the examination is useful for my analyses are there are no reasons to expect the content and grading of the tests will change in response to reforms in Ghana only.

Tertiary institutions in Ghana are either public or private, and universities[7] account for about

[5]These countries are the Gambia, Liberia, Nigeria, and Sierra Leone.
[6]At the beginning of high school, students are assigned to specialized fields of study.
[7]I use the term College and University interchangeably

73% of total enrollment. Like the United States and many other countries, the college market in Ghana is decentralized. There is no limit to the number of universities a student can apply to, although each has a financial and time cost, among others. The crucial decision of field of study in college is made at the application stage in a setting where the assignment is usually immediate acceptance/Boston mechanism as opposed to deferred acceptance. A student generally applies to a college program combination[8] and switching after admission is often costly. A prospective applicant has a limited number of choices to specify, and a key consideration for admission is a composite score determined from subjects grades at the WASSCE.

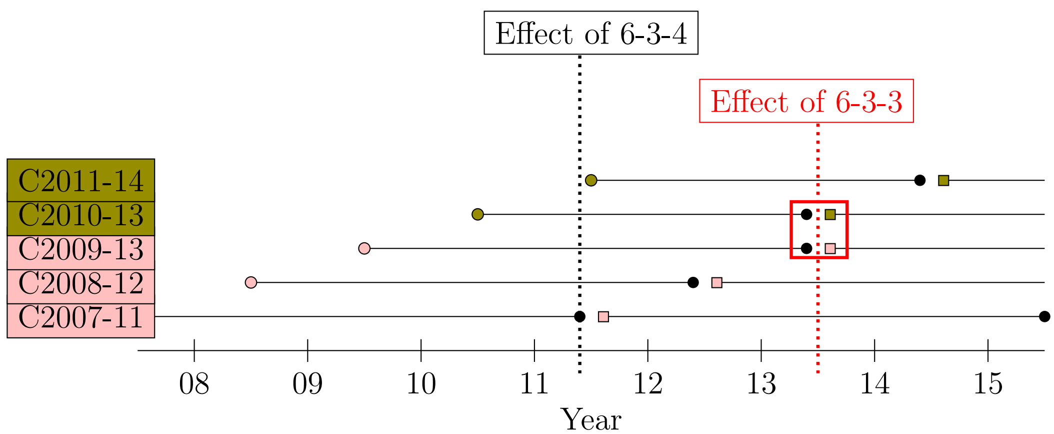


Figure 1
Timeline of Reforms and Affected High School Cohorts

Notes: The figure plots the timeline of the four-year and three-year reforms and the affected high school cohorts. On the y-axis, the year of entry for each high school cohort and the year of graduation is indicated. Pink cohorts have a duration of four years; Olive cohorts have a duration of three years; colored circle - year of entering high school; black circle - year of graduating high school given smooth progression; colored square - earliest year to enter college after high school graduation. Vertical dotted lines mark the year of the first cohort graduating high school for each reform as described. The red square marks the double cohort graduating high school.

III Data and Summary Statistics

To study the impact of graduating in an increased cohort size on performance, decisions of prospective college applicants, and final admission outcomes on the college education market, I use administrative data on all students who participated in the terminal examinations at the end of

[8] For example, apply to college A for a Bachelor of Arts in Economics, Mathematics, and Statistics

middle school and high school and application data from the University of Ghana (UG), a large, prestigious, public university. The examination datasets were obtained from the West African Examinations Council, which administers them. My main empirical strategies merge these three datasets.

For my first empirical strategy using a cohort analysis, I obtain my sample by merging all students who participated in the WASSCE from 2007 to 2017 with UG's application data using a unique year-examination identification number pair in both datasets. Figure 2 shows the trends of high school graduates and UG applicants over this period. In the left panel, the double cohort results in a 135% increase in the cohort graduating high school. The right panel shows the demand shock in the college education market with a 56% increase in undergraduate applicants. The high school data includes letter grades for each subject, full names, gender, and date of birth. Variables in UG's application data are gender, date of birth, up to three ranked choices, and an indicator for whether the applicant was offered admission or not and what program was offered.

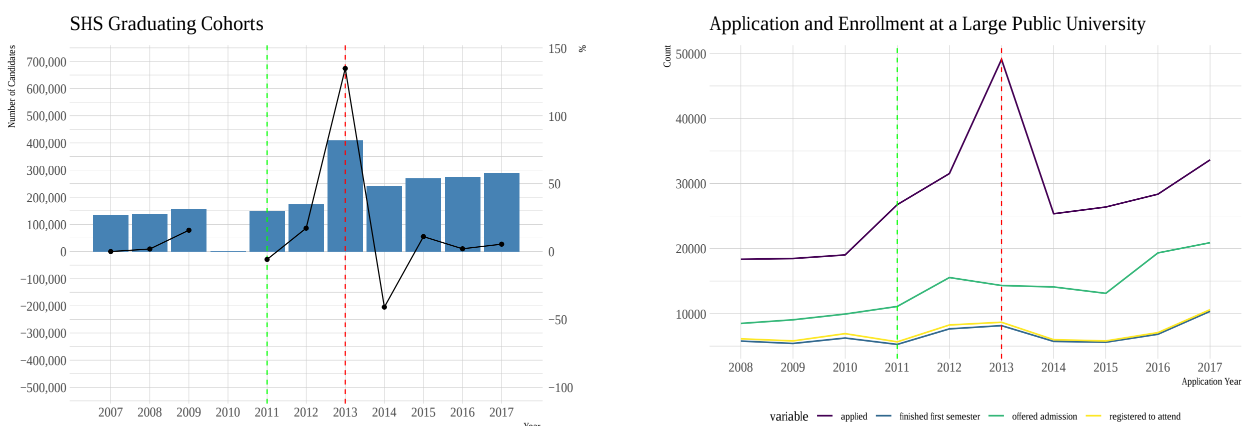


Figure 2
Graduation, Application and Enrollment Trends

Notes: The left panel shows the number of high school graduates nationwide and year-on-year changes on the right axis. In 2010, no cohort graduated high school because of the introduction of the extra year. The right panel displays the application and enrollment trends at UG. The dashed green vertical line marks the year the first cohort in the four-year reform graduated and the dashed red line marks the year the double cohort graduated in both panels.

The sample for my second empirical strategy, RDD, builds on the cohort analysis sample and merges it with all students who completed middle school on time from 2004 to 2014. Under the assumptions of starting school in the year she turns six and smooth progression (no grade skipping, repeating, or breaks), a student completes middle school on time if she graduates in the year she turns fifteen. The cohort analysis sample and the middle school data do not have a common unique identification number, therefore, I implement approximate matching methods with full names, dates of birth, and gender. The middle school data also includes students' grades at the terminal examination. The RD sample gives panel data where I see middle school graduates who furthered their education and graduated high school and their decisions and outcomes on the college education market.

I have three main outcomes: short-term performance based on grades at the high school terminal examination, students' decisions to apply to college upon graduation, and admission outcomes on the college market. Short-term performance is measured by a composite score based on subject grades in the high school terminal examination. This score, known as the aggregate score, is the main criterion for college admissions. I compute aggregate scores and normalize them to range from the lowest score of 0 to 48. A description of how this score is calculated is included in the appendix. Outcomes related to students' decisions on the college market are indicator variables for whether a student applied to college immediately after she graduated high school or within two years. I also consider whether she applied immediately and her first choice is a 'prestigious' program or has a cutoff above the median. Program cutoffs range from an aggregate score of 30 to 48, and I define a prestigious program as one with a cutoff of 44 or higher[9]. Admission outcomes are indicators for being offered admission conditional on having applied.

Like most administrative datasets, my datasets have limited individual demographic characteristics for relevant heterogeneous analysis. In spite of this, in addition to gender, I present results on heterogeneous effects of graduating high school in an increased cohort for economically

[9] Prestigious programs over this period were BSc. Administration, Bachelor of Pharmacy, Medicine and Surgery, Dental Surgery, Law, and BSc. Nursing.

vulnerable students by using a coarse measure based on likely region of residence. In the RD sample, I extract the administrative region of the student's middle school embedded in their examination identification number and use this as a proxy for socioeconomic status. The Ghana Statistical Service has developed a national poverty incidence map based on the 2010 population census and the sixth round of the Ghana Living Standards Survey, which uses data collected in 2012/2013. Each administrative region has a poverty index ranking, which I impute in my data. Middle schools in Ghana are unlike most high schools, which are boarding schools. Their locations are, therefore, reasonable proxies for students' regions of residence.

Public universities account for approximately 60% of all enrollment in tertiary institutions. There were six public universities in 2011 and this increased to nine in 2012. Table 1 displays the proportion of UG enrollment relative to all public university enrollments. UG accounted for between 19% to 34% of enrollments on average between 2011 and 2015. Figure A.5 in the appendix shows application and enrollment trends for all public and private universities mirror a pattern similar to the University of Ghana's.

Table 1
UNIVERSITY OF GHANA SEATS v ALL PUBLIC UNIVERSITIES

Year	**All Public Seats**	**UG Seats**	**UG Seats/ All Public Universities**	
			lower bound %	*upper bound%*
2011	66,589	11,096	16.66	29.75
2012	74,173	15,544	20.96	37.41
2013	70,901	14,318	20.19	36.05
2014	69,763	14,094	20.20	36.06
2015	82,913	13,113	15.82	28.23

Notes: Summary of undergraduate enrollment in the University of Ghana (UG) relative to all public universities in Ghana from 2011 to 2015. Data on enrollment in all public universities was obtained from the 2016 Statistical Report, National Council for Tertiary Education, Ghana. This report does not clarify if the totals include post-graduate enrollment. I, therefore, calculate a lower and upper bound of UG undergraduate enrollment. The lower bound assumes all the seats in the public universities are undergraduate and the upper bound assumes 56.02% are undergraduate as this is the percentage of the total student population in Bachelor or equivalent programs per the same report.

IV Empirical Strategy

I employ two empirical strategies: a cohort analysis and a regression discontinuity design to identify the effect of graduating in an increased cohort size on academic performance at the end of high school and students' decisions and admission outcomes in the college education market. In the cohort analysis, I consider high school graduating cohorts and compare the outcomes of interests for students in the double cohort and otherwise. To address concerns about the possibility of the reforms affecting the timing of high school graduation and selection bias in the cohort analysis, I leverage the compulsory elementary school starting law and use a regression discontinuity design with dates of birth as the running variable.

IV.1 Cohort Analysis

Regression results for comparing students who graduated high school in the double cohort with those in single cohorts focus on students in the four-year reform. Recall that these are students with a high school duration of four years. Excluding cohorts with three years in high school ensures that estimates are not confounded by years of schooling, which can directly affect the outcomes and the likelihood of graduation. Furthermore, the effect of graduating in a large cohort can differ by duration in high school, as I show in my findings, indicating that composition or source of the increase matters. My restricted sample covers all three cohorts in the four-year reform from 2011 to 2013, where the students in 2013 are in the double cohort. I estimate the equation:

$$Y_{ics} = \alpha_0 + \beta gradDC + X'_{ics}\gamma + \mu_s + \varepsilon_{ics} \tag{1}$$

Y_{ics} is the aggregate score at the end of high school or an indicator variable for the decision or outcome on the college education market for student i in graduating cohort c in school s. $gradDC$ is the treatment of interest capturing an increased cohort size. It is a binary variable equal to 1 if a high school student graduates in the double cohort and 0 otherwise. I include controls for gender, the month of birth, and age at high school terminal examination in X_{ics}. My preferred specification also includes high school fixed effects to control for unobservable school characteristics that do not vary over time. For outcomes on students' application decisions, I include a linear trend as the share of each cohort applying to college has been increasing steadily over time. The results are discussed in section V.

IV.2 Regression Discontinuity Design

Implementing the cohort analysis with high school graduates raises concerns about potential outcomes differing systematically across cohorts due to unobserved differences and the possibility of the reforms affecting the timing of high school graduation. To address these concerns, I leverage the compulsory elementary school start age and employ a regression discontinuity design with a sample considering students who graduate middle school. This starting point should be reasonably free from any effect of the high school reforms.

The requirement to begin elementary school in the calendar year a student turns six implies that for each year, sharp discontinuities are expected in the school start cohort on January first of each year, which should translate into discontinuities in students' high school graduating cohort. Under the assumption that a student begins elementary school when she is supposed to and progresses smoothly, I can determine her expected middle school graduating cohort. If she furthers her education and completes high school, I can also resolve her expected high school cohort under the same assumptions.

With these assumptions, all students in the four-year reform should have been born from 1992 to 1994. Students born in 1992 or 1993 will be in single cohorts, and those born in 1994 will be in the double cohort. This presents an opportunity to compare students born on January 1st, 1994, or later with those born just before. Formally, I implement a regression discontinuity design with students' dates of birth as the running variable where I normalize the cutoff, 01-01-1994, to zero as the center and recalibrate dates of birth before and after with respect to the center. Dates of birth before 01-01-1994 will be negative, and those after the cutoff will be increasingly positive.

The identifying assumption is as if random assignment around the cutoff so that all other relevant characteristics are, on average similar except for high school graduation year.

As discussed in section II, imperfect compliance with the schooling law, grade repeating, skipping, and breaks are prevalent; thus, for students around this cutoff, their graduating cohort will not perfectly match their expected cohort. The RD, therefore, becomes a fuzzy regression discontinuity design where being born on or after 01-01-1994 causes a discontinuity in the likelihood of graduating in the double cohort in the four-year reform. Being born on or after 01-01-1994 essentially becomes an instrument for graduating in the double cohort. In this setting, the prevalence of imperfect compliance and irregular progression, coupled with the fact that the four-year reform was implemented for only three years, means that excessive variation in graduating cohorts around the cutoff will violate the identifying assumption if some of these students graduate in the three-year reform. A review of all middle school participants in the terminal examination shows many do not graduate in their expected cohorts. I detail in the next section the varied graduation cohorts around the cutoff and the method I employ to address this challenge.

IV.2.1 Timing of Graduation and Compliance to School Start Age

Less than 25% of middle school students graduate in their expected graduation year, and the majority graduate later. For middle school students who took part in the terminal examination from 2004 to 2014 and were born between 1990 to 1997, Table 2 shows the timing of their graduating cohort relative to their expected graduating cohort. A student graduates middle school early, on time, or late if she graduates before, matches, or after her expected graduating year. In Panel A, 81% of middle school students graduate late on average. Unsurprisingly, not many students graduate early, and only about 16% graduate on time. Students born in earlier years, such as 1990, are mechanically more likely to be present in my dataset if they graduated late, whereas some students born in later years, like 1997, will not be captured if they graduated after 2014 when my data ends. Restricting the sample to students who graduated up to two years later in panel B shows the proportion of students who graduate early, on time, or late is similar each year. Even with this restriction, not more than 25% graduate on time.

Table 2
MIDDLE SCHOOL GRADUATION RELATIVE TO EXPECTED COHORT

Birth Year	**Full Sample** *Panel A*			**Restricted Sample** *Panel B*		
	early	*ontime* %	*late*	*early*	*ontime* %	*late*
1990	2.2	13.4	84.4	3.9	23.5	72.7
1991	2.6	14.6	82.8	4.0	24.0	71.9
1992	2.4	12.8	84.8	3.7	21.1	75.2
1993	2.4	14.0	83.6	3.6	22.6	73.8
1994	2.5	14.8	82.6	3.8	23.8	72.4
1995	2.9	15.4	81.7	3.9	22.7	73.4
1996	3.4	17.6	79.0	4.0	23.0	73.0
1997	5.8	24.6	69.6	5.3	24.7	70.0

Notes: Middle school graduating cohort relative to expected graduating cohort given date of birth and smooth progression in each calendar year indicated. early: middle school cohort is before the expected cohort. On time: middle school cohort is the same as expected. late: middle school cohort is after the expected cohort. Panel A considers all middle school students who wrote the terminal examination from 2004 to 2014 and were born in the years specified. Panel B restricts the sample to students who graduate up to 2 years later than expected.

With many middle school students graduating late, those born around the relevant cutoff, 01-01-1994, who complete high school will transverse different durations in high school. Table 3 illustrates this for those born in December 1993 and January 1994. Students born in December 1993 should graduate middle school in 2008, and should they go on to high school, graduate in 2012, a single cohort in the four-year reform. On the other hand, students born in January 1994 should graduate middle school in 2009 and high school in 2013, part of the double cohort in the four-year reform. From table 3, middle school graduating cohorts span multiple years, which feeds into high school graduating cohorts with different durations. To not confound the treatment effect of graduating in an increased cohort with duration, I have to impose specific restrictions on my final sample for analysis.

Table 3
ILLUSTRATION OF MULTIPLE GRADUATION COHORTS AROUND CUTOFF

Middle School Graduating Cohort	**Birth Month and Year** *December 1993*	*January 1994*	**Expected High School Graduating Cohort**
2006	0.11	0.06	2009_3
2007	1.17	0.27	2011_4
2008	11.11	5.03	2012_4
2009	23.74	18.25	2013_4
2010	23.50	20.67	2013_3
2011	19.02	20.31	2014_3
2012	12.02	15.98	2015_3
2013	6.39	12.99	2016_3
2014	2.94	6.46	2017_3
Total - %	100	100	
Total - count	25,473	23,640	

Notes: Highlighting multiple middle school graduating cohorts and expected high school graduating cohorts for students born +31 days around the relevant cutoff, 01-01-1994. The high school year is augmented to include the duration of high school based on the reforms implemented. For example, 2012_4 means graduating in 2012 which is in the four-year reform. 2013 is the double cohort year.

IV.2.2 Sample Restrictions and Estimating Equation

I restrict the population of all middle school students to those who complete middle school on time and match this to high school graduates in the four-year reform to tighten the span of multiple graduation years around the relevant cutoff. Graduating middle school on time is unlikely to be affected by the reforms that changed the duration of high school. With this restriction, I estimate the following equation:

$$y_i = \beta_0 + \beta_1 \text{after}_i + f(\text{day}_i) + \varepsilon_i \tag{2}$$

where y_i is either an indicator for graduating in the double cohort for the first stage or an outcome of interest for student i for reduced form estimates. The variable of interest, after_i is an indicator for a student born on or after 01-01-1994 and $f(\text{day}_i)$ is a parametric or non-parametric function of the running variable, day of birth. Other covariates, such as gender, are included in some specifications. My preferred bandwidth is $+/-180$ days around the cutoff. I include robustness checks of the results in the appendix using smaller bandwidths and the optimal bandwidth specified by Calonico et al. (2014).

IV.2.3 Validity of the Instrument

I now consider the factors that make instrumenting for graduating in the double cohort using date of birth valid. A good instrument should have a causal effect on the treatment of interest, be as good as randomly assigned, and meet the exclusion restriction. Furthermore, the monotonicity assumption should hold.

Relevance assumption: Figure 3 shows the first stage for the sample under consideration. Being born on or after the cutoff increases the likelihood of graduating in the double cohort with a discontinuous jump of 0.73.

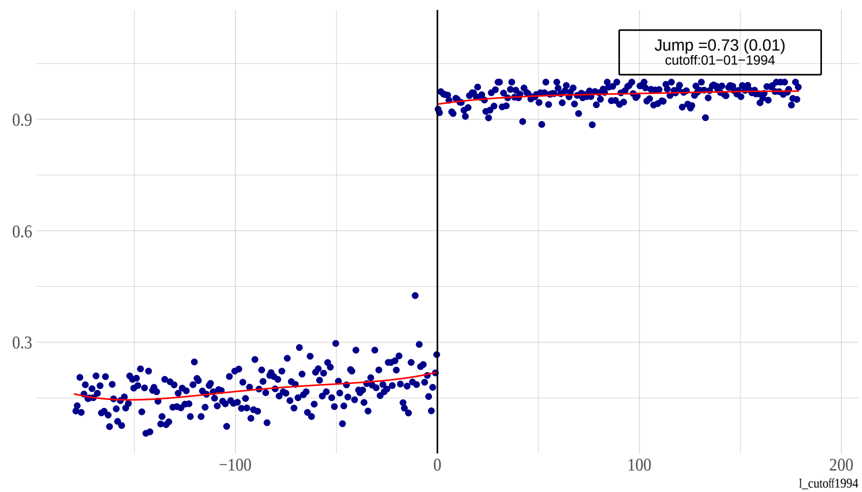


Figure 3
First Stage - Graduating in the Double Cohort

Notes: This figure plots binned means as detailed in Calonico et al. (2015) for the analysis sample of middle school students who graduated on time matched to students who graduated high school in the four-year reform. The outcome is an indicator for graduating high school in the double cohort, and the jump size at the discontinuity is indicated in the box in the top right corner.

Independence assumption: Births around the cutoff are random. However, measurement error may exist on the recorded date of birth. Histograms of dates of birth for all middle school and high school graduates in the data show a spike in the density of students born on 01-01. This spike is also present on month-days such as 02-02, 22-02, 03-03, 04-04, 12-12, and holidays like Ghana's independence day and Christmas day. Figure A.2 in the appendix shows the histogram for all middle school graduates from 2004 to 2014. Replicating these histograms for a household dataset[10] outside of my analysis shows the same trend. Anecdotal evidence on how dates of birth are recorded suggests that a student's month and year of birth will be accurate even if the day in the month is not. As a result, any measurement error in dates of birth should not be across the cutoff. Figure A.1 shows the McCrary Density Manipulation test, which captures this spike. It is worth noting that unlike countries such as the United States, where any bunching identified for dates of birth is on December 31st, there is none here. Figure A.7 shows no significant discontinuity for the pre-treatment variable, mathematics grade, at the end of middle school.

Exclusion Restriction: By default, students born on January 1st are likely to be older in their cohorts. The exclusion restriction assumption will not be satisfied if relative age independently affects schooling outcomes. I follow Malamud et al. (2021) and implement a difference in regression discontinuity (D-RD) design to account for the independent effect of relative age on performance and college outcomes as a robustness check. Using Norwegian data, Black et al. (2011) show a positive impact on schooling outcomes thus, any negative effects in the standard regression discontinuity design could be considered a lower bound. I include a control treatment 01-01-1993, where the double cohort should have had minimal impact to verify this.

$$y_i = \beta_0 + \beta_1 \text{after}_i + \beta_2 \text{treated}_i + \gamma(\text{after}_i \times \text{treated}_i) + f(\text{day}_i) + \varepsilon_i \tag{3}$$

Equation (3) shows the reduced form estimating equation for the D-RD where y_i is an outcome of interest for student i. $treated_i$ is an indicator for students born around 01-01-1994 and the coefficient of interest is γ, for the variable $after_i \times treated_i$, which captures the difference in

[10] Yale household survey data

discontinuity in the control and treated cutoffs. after_i and $f(\text{day}_i)$ are as previously defined. Other covariates, such as gender, are included in some specifications.

V Findings

An increased cohort size generally has adverse effects on my three outcome categories: short-term performance, students' decisions on the college education market relating to the timing of their application, the selectivity of their first choice field, and finally, market outcomes on admission chances. For each category, I first present results from the cohort analysis, and then the RD. A striking difference between the cohort analysis sample and the RD sample is that the former includes all high school graduates in the four-year reform, whereas the latter is a subset of students who graduated middle school on time. Ex-ante, it is plausible that students in the RD sample have high ability and socioeconomic status on average. Control means are presented in each table to anchor the magnitude of coefficient estimates, and they highlight the differences as expected. Heterogeneous results by gender and economic vulnerability are based on the RD design.

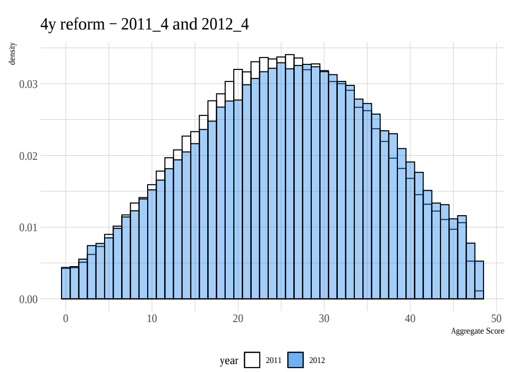
V.1 Increased Cohort Size and Short-Term Performance

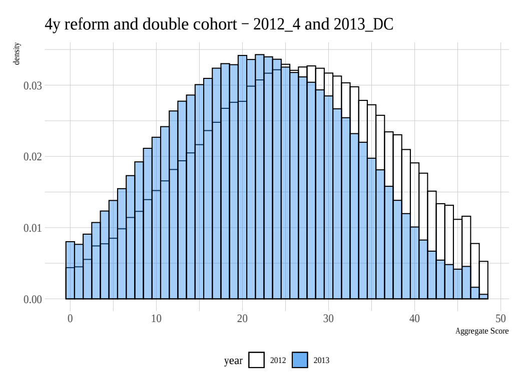
From both the cohort analysis and the RD design, I find that graduating high school in an increased cohort size results in a significant fall in short-term performance. Academic performance, measured by the aggregate score from the high school terminal examination, falls by at least 20% standard deviation.

V.1.1 Cohort Analysis

The aggregate score distributions of high school graduates under the four and three-year reforms reveal that graduating in the double cohort impacts performance. A surprising finding is a differential effect by duration in high school. Figure 4 shows these comparisons for each high school graduating cohort in year t and $t+1$ from 2011 to 2015. 2011 and 2012 as single cohort years in the four-year reform. 2013 is the double cohort year, and 2014 to 2015 are single cohorts in the three-year reform. In the top left panel, the score distributions for the two single cohorts under the four-year reform show no significant difference as they fairly overlap. This also holds for the first two single cohorts in the three-year reform shown in the bottom right panel. In the top right panel, however, comparing the last single cohort year in the four-year reform to the double cohort, I find that graduating in the double cohort year results in worse performance. On the other hand, the bottom left panel shows a contrasting effect of improved performance when compared with the first cohort in the three-year reform.

A first-order confounding factor of this comparison is the mixed duration in the double cohort, where about half are in the four-year reform and the other in the three. Existing evidence shows duration in school impacts performance. To separate these effects, I split the double cohort by duration in high school. Figure 5 shows this decomposition. Not surprisingly, duration in high school has a positive effect on performance, however, graduating in an increased cohort size has a differential effect by duration. Students in the double cohort in the four-year reform performed worse when compared to their counterparts in the single cohort. In contrast, students in the double cohort in the three-year reform performed better in a similar comparison. This puzzle suggests different mechanisms at play depending on the composition of the increased cohort, in this case, different duration.





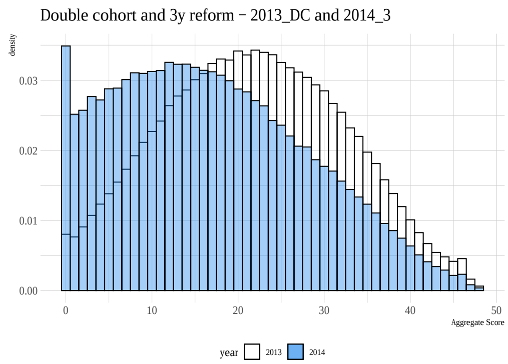


Figure 4
Short-Term Performance: Aggregate Score Distributions

Notes: This figure plot the aggregate score distributions of all high school graduates. Each panel compares the distribution of the graduating cohort t with $t+1$ from 2011 to 2015. Scores range from 0 to 48, and a higher score implies better performance. Headings for each panel include the duration for each cohort. For example, 2012_4 is the 2012 high school cohort with four years of high school. DC means double cohort.

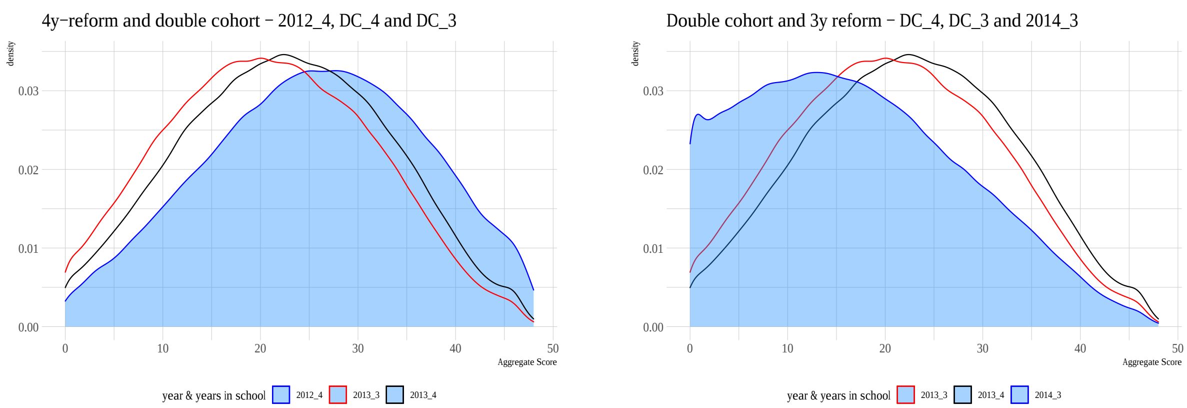


Figure 5
Decomposition of Aggregate Score in Double Cohort by Duration

Notes: This figure shows a decomposition of the double cohort graduation year (2013) by duration in high school. **Left panel**: Compares the decomposed double cohort with the last single cohort in the four-year reform (2012); **Right panel**: Compares it with the first single cohort in the three-year reform (2014). Scores range from 0 to 48, and a higher score implies better performance. Headings for each panel include the duration for each cohort. For example, 2012_4 is the 2012 high school cohort with four years of high school. DC means double cohort.

In the school "size" literature - class, school, entering cohort size - the underlying mechanism generally suggested is through resources per person, where fewer resources per student can potentially lead to worsening outcomes. My findings in figure 5, however, suggest that resources per person cannot be the only relevant mechanism at play given that students who graduate in the double cohort in the three-year reform perform better than their counterparts in the subsequent single cohorts. I discuss a plausible explanation in section V.6.

Table 4 presents the results for students in the four-year reform from regression equation (1) in section IV and reiterates the results seen in the aggregate distributions in figures 4 and 5. My preferred specification includes school fixed effects in column (2). It shows that students graduating in the double cohort have a 19% standard deviation reduction in their aggregate score given a control mean of 0.56. These results are stable with or without school fixed effects.

Table 4
COHORT ANALYSIS ESTIMATES OF EFFECTS ON PERFORMANCE

	Treatment: *Graduated in the Double Cohort*	
Dependent Variables	(1)	(2)
High school test score		
Aggregate score	-0.201^{***}	-0.194^{***}
	(0.003)	(0.017)
Control Mean	0.56	0.56
High School FE	no	yes
Num. obs.	469,822	469,822

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Notes: Ordinary least squares estimates of graduating high school in an increased cohort size on short-term performance as measured by the aggregate score at the high school terminal examination. Cohort size is measured as a binary variable where an increased cohort size = 1 if graduated in the double cohort and 0 if graduated in a single cohort. The sample is restricted to students with four years in high school. Column (1) includes month of birth, age at examination, and gender as controls. Column (2) adds high school fixed effects. The control mean captures the average aggregate score in the control group.

V.1.2 RD Specification

Results from the RD corroborate the findings in the cohort analysis for the subset of students who graduated middle school on time; graduating in the increased cohort size leads to reduced short-term performance. Table 5 shows the reduced form estimates for $after$ on performance as specified in equation (2). The aggregate score falls by 35% of a standard deviation. Columns (2) and (3) show the ordinary least squares(OLS) and two-stage least squares(2SLS) estimates. These estimates do not widely vary, and a comparison of the OLS and 2SLS results suggests a minimal presence of selection bias in the OLS estimates. Comparing the control means in the cohort analysis and the RD samples highlight their innate difference. The latter population is likelier to have a high SES and average ability, and control means reflect this. Figure 6 shows graphically the non-parametric results with no controls described by Calonico et al. (2014).

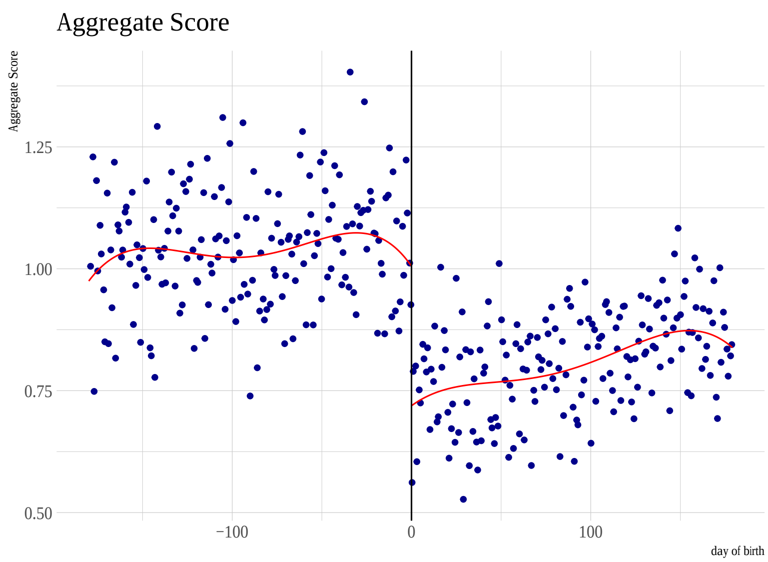


Figure 6
RD Estimates of Effects on Short-Term Performance

Notes: This figure plots binned means as detailed in Calonico et al. (2015) for the analysis sample of middle school students who graduated on time matched to students who graduated high school in the four-year reform. The outcome is the standardized aggregate score from the high school terminal examination.

V.2 Increased Cohort Size and Students' Decisions

In response to the increased cohort size, students are less likely to apply to the University of Ghana immediately after graduating high school, and this persists even two years after graduation. For

Table 5
RD ESTIMATES OF EFFECTS ON PERFORMANCE

	Treatment: *Graduated in the Double Cohort*		
	RDD (1)	*OLS* (2)	*2SLS* (3)
First Stage			
Graduated in DC	0.727^{***}		
	(0.013)		
Outcomes			
Aggregate score	-0.347^{***}	-0.582^{***}	-0.470^{***}
	(0.034)	(0.016)	(0.030)
Control Mean	1.04	1.04	1.04
Num. obs.	28,172	28,172	28,172

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Notes: Parametric RD estimates of effects on graduating high school in an increased cohort size on short-term performance as measured by the aggregate score at the high school terminal examination. Cohort size is measured as a binary variable where an increased cohort size = 1 if graduated in the double cohort and 0 if graduated in a single cohort. A bandwidth of 180 days. The sample is restricted to students who completed grade 9 "on time" based on their date of birth and smooth progression and completed high school in the four-year cohorts. Column (1): Reduced form estimates, including first stage estimate. Column (2): OLS estimates. Column (3): 2SLS estimates where graduating in the double cohort in instrumented by being born on or after January 1st, 1994.

graduates who ever applied to the UG from 2007 to 2015, figure A.4 in the appendix reveals that most did so within two years of graduation. The persistent lower likelihood of applying even after two years, therefore, indicates students are not just postponing entry into the college market; they are forgoing it altogether. These results are consistent with de Roux and Riehl (2022), who show that an academic break after high school for students in Colombia resulted in many forgoing college.

V.2.1 Cohort Analysis

The likelihood of applying to college for high school graduates in the four-year reform double cohort falls by (3.5pp) 35%, and even after two years, they still trail behind by (2.9pp) 19%. Students are (1.5pp) 50% less likely to apply to prestigious programs such as medical school and law and also reduce the selectivity of their first choice program. The latter is evinced in the (3.6pp) 40% lower likelihood of selecting a first choice with a cutoff above the median. Table 6 displays these results in column (2). These results are not sensitive to excluding high school fixed effects in column (1). The high school aggregate score is the main criterion for college admission. To separate the effect of graduating in the double cohort beyond its channel through the aggregate score, columns (3) and (4) in table 6 augment the specifications in columns (1) and (2) by controlling for the aggregate score. These results show an additional effect as students are still less likely to apply immediately and to selective programs. My preferred specification includes high school fixed effects. These results are, however, sensitive to the exclusion of fixed effects in column (3).

V.2.2 RD Specification

Table 7 summarizes the reduced form estimates of the adverse impact on students' decisions in columns (1) and (4). I report the first stage coefficient, which was presented graphically in figure 3 in section IV. The estimates in column (1) indicate that students born on or after the cutoff who graduate middle school on time reduce their likelihood of applying to college by (6.8pp) 26% with persistence up to two years. These students are also less likely to apply to a selective

Table 6
COHORT ANALYSIS ESTIMATES OF EFFECTS ON STUDENT DECISIONS

		Treatment: *Graduated in the Double Cohort*			
		No Aggregate Score Control		*Aggregate Score Control*	
Dependent Variables	*Control Mean*	(1)	(2)	(3)	(4)
Applied Immediately	0.10	-0.029^{***}	-0.035^{***}	0.002	-0.021^{***}
		(0.002)	(0.004)	(0.002)	(0.003)
Applied within 2 years	0.15	-0.023^{***}	-0.029^{***}	0.020^{***}	-0.001
		(0.002)	(0.004)	(0.002)	(0.003)
Applied Prestigious Immediately	0.03	-0.012^{***}	-0.015^{***}	-0.001	-0.010^{***}
		(0.001)	(0.002)	(0.001)	(0.002)
First choice cutoff above median	0.09	-0.031^{***}	-0.036^{***}	-0.005^{**}	-0.024^{***}
		(0.002)	(0.004)	(0.002)	(0.003)
High School FE		no	yes	no	yes

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Notes: Ordinary least squares estimates of graduating high school in an increased cohort size on students' decisions on the college education market. Cohort size is measured as a binary variable where an increased cohort size = 1 if graduated in the double cohort at the end of high school and 0 if graduated in a single cohort. The outcomes, from the top are: Indicator for applying to college immediately after graduation, indicator for applying to college within two years, indicator for applying immediately to a "prestigious" program as a first choice and Indicator for applying immediately and selecting a first choice with a cutoff above the median. Prestigious is defined as a program with a cutoff above 44. The sample is restricted to students with four years in high school. Column (1) includes month of birth, age at examination, gender, and a linear trend as controls. Column (2) additionally contains high school fixed effects. Columns (3) and (4) add to the controls in (1) and (2) the score on the high school terminal examination. The control mean captures the average value for each outcome in the control group.

program, but there is no significant difference for the most prestigious programs. Unlike in the cohort analysis, the reduction in the likelihood of applying to college and selectivity appears to be primarily driven by the effect on the aggregate score. After considering this, students are not significantly different in their entry decisions, although there is some evidence that they are less likely to apply within two years. I also include OLS and 2SLS specifications for comparison. Once again, as expected, the control means of students' application decisions are at least twice that of the cohort sample. Figure 7 shows graphically the non-parametric results with no controls and reiterates the parametric findings.

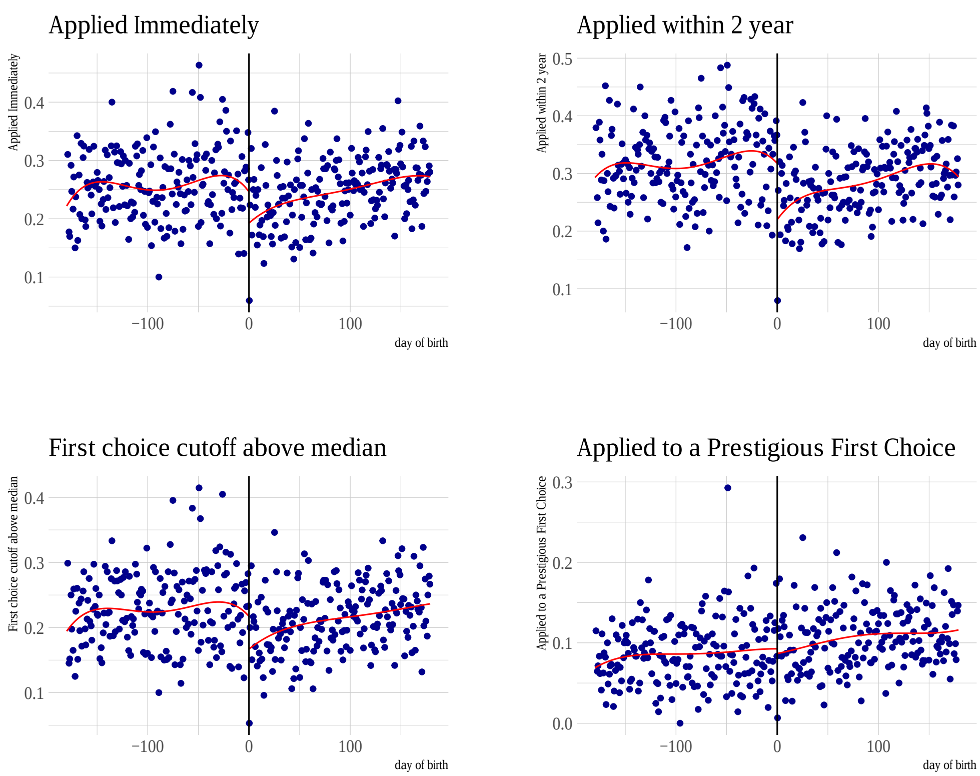


Figure 7
RD Estimates of Effects on Students' Decisions

Notes: This figure plots binned means as detailed in Calonico et al. (2015) for the analysis sample of middle school students who graduated on time matched to students who graduated high school in the four-year reform. The outcomes, beginning from the left in the top panel are: Indicator for applying to college immediately after graduation, Indicator for applying to college within two years, Indicator for applying immediately and selecting a first choice with a cutoff above the median, and indicator for applying immediately to a "prestigious" program as a first choice. Prestigious is defined as a program with a cutoff above 44.

Table 7
RD ESTIMATES OF EFFECTS ON STUDENT DECISIONS

		Treatment: *Graduated in the Double Cohort*					
		No Aggregate Score Control			*Aggregate Score Control*		
		RDD	*OLS*	*2SLS*	*RDD*	*OLS*	*2SLS*
	Control Mean	(1)	(2)	(3)	(4)	(5)	(6)
First Stage							
Graduated in DC		0.727^{***}			0.705^{***}		
		(0.013)			(0.013)		
Outcomes							
Applied Immediately	0.26	-0.068^{***}	-0.116^{***}	-0.083^{***}	-0.000	-0.003	0.011
		(0.016)	(0.007)	(0.015)	(0.015)	(0.007)	(0.014)
Applied within 2 years	0.32	-0.110^{***}	-0.157^{***}	-0.125^{***}	-0.032^{*}	-0.026^{***}	-0.017
		(0.017)	(0.008)	(0.015)	(0.016)	(0.007)	(0.015)
Applied Prestigious Immediately	0.09	-0.005	-0.020^{***}	-0.002	0.023^{*}	0.026^{***}	0.037^{***}
		(0.011)	(0.005)	(0.010)	(0.011)	(0.005)	(0.010)
First Choice Cutoff above median	0.23	-0.057^{***}	-0.107^{***}	-0.076^{***}	0.001	-0.011	0.004
		(0.016)	(0.007)	(0.014)	(0.015)	(0.007)	(0.014)

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Notes: Parametric RD estimates of effects on graduating high school in an increased cohort size on students' decisions on the college market. Cohort size is measured as a binary variable where an increased cohort size = 1 if graduated in the double cohort and 0 if graduated in a single cohort. The outcomes, from the top are: Indicator for applying to college immediately after graduation, indicator for applying to college within two years, indicator for applying immediately to a "prestigious" program as a first choice and Indicator for applying immediately and selecting a first choice with a cutoff above the median. Prestigious is defined as a program with a cutoff above 44. A bandwidth of 180 days. The sample is restricted to students who completed grade 9 "on time" based on their date of birth and smooth progression and completed high school in the four-year cohorts. Columns (1) and (4): Reduced form estimates, including first stage estimate. Columns (2) and (5): OLS estimates. Columns (3) and (6): 2SLS estimates where graduating in the double cohort is instrumented by being born on or after January 1st, 1994. Columns (1) - (3) control for gender, and (4) - (6) add the aggregate score at the high school terminal examination.

V.3 Increased Cohort Size and College Education Market Outcomes

Final market outcomes on admission chances highlight strong supply-side constraints. Conditional on college applications, students are at least 41% less likely to receive an admission offer. These results are similar for the entire sample of students who graduate high school in the cohort analysis and for the RD sample, which subsets middle schoolers who graduate on time. The fact that colleges are unwilling or unable to absorb this demand shock is stark.

V.3.1 Cohort Analysis

For all high school graduates in the four-year reform, conditional on applying to college immediately, chances of being offered admission fall drastically by (29pp) 50%. Table 8 shows the results. Interestingly, the effect of graduating high school on admission chances conditional on applying immediately is the same as the admission chances of being offered your first choice. Students applying to the University of Ghana can specify up to three ranked choices. The similarity in the coefficients emphasizes oversubscription to the university with little room to consider choices beyond the first rank choice. Adding this to an environment where the assignment is immediate acceptance, makes the first choice very critical. Being offered admission depends on your aggregate score, so to identify pure supply-side constraints, columns (3 - 4) control for the aggregate score. Despite being equally qualified, students who graduate in the double cohort are (20pp) 41% less likely to be offered admission overall, with a similar fall for prestigious programs.

V.3.2 RD Specification

Reduced form estimates for the sample of middle schoolers who graduated on time corroborate the strong supply-side constraints. Table 9 reports these estimates in column (1) with the additional effect after considering the aggregate score shown in column (4). OLS and 2SLS estimates are reported in columns (2) and (3) with their additional effects after controlling for the aggregate score reported in (5) and (6) for comparison. These results are very stable across all specifications. Figure 8 shows graphically the non-parametric results with no controls and reiterates the

Table 8
COHORT ANALYSIS ESTIMATES OF EFFECTS ON COLLEGE MARKET OUTCOMES

		Treatment: *Graduated in the Double Cohort*			
		No Aggregate Score Control		*Aggregate Score Control*	
Dependent Variables	*Control Mean*	(1)	(2)	(3)	(4)
Offered admission given applied immediately	0.57	-0.291^{***}	-0.292^{***}	-0.199^{***}	-0.199^{***}
		(0.004)	(0.014)	(0.004)	(0.009)
Offered admission given applied within 2 years	0.54	-0.187^{***}	-0.201^{***}	-0.101^{***}	-0.103^{***}
		(0.004)	(0.013)	(0.003)	(0.009)
Prestigious choice offered given applied immediately	0.30	-0.166^{***}	-0.166^{***}	-0.106^{***}	-0.102^{***}
		(0.006)	(0.017)	(0.005)	(0.011)
First choice offered given applied immediately	0.57	-0.291^{***}	-0.292^{***}	-0.199^{***}	-0.199^{***}
		(0.004)	(0.014)	(0.004)	(0.009)
High School FE		no	yes	no	yes

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Notes: Ordinary least squares estimates of graduating high school in an increased cohort size on final college market outcomes on admission chances. Cohort size is measured as a binary variable where an increased cohort size = 1 if graduated in the double cohort at the end of high school and 0 if graduated in a single cohort. The outcomes, from the top are: Indicator for being offered admission conditional on applying to college immediately after graduation, indicator for being offered admission conditional on applying to college within two years, indicator for being offered admission conditional on applying immediately to a "prestigious" program as a first choice and indicator for being offered admission to your first choice conditional on applying to college immediately after graduation. Prestigious is defined as a program with a cutoff above 44. The sample is restricted to students with four years in high school. Column (1) includes month of birth, age at examination, gender, and a linear trend as controls. Column (2) additionally includes high school fixed effects. Columns (3) and (4) add to the controls in (1) and (2) the score on the high school terminal examination. The control mean captures the average value for each outcome in the control group.

parametric findings.

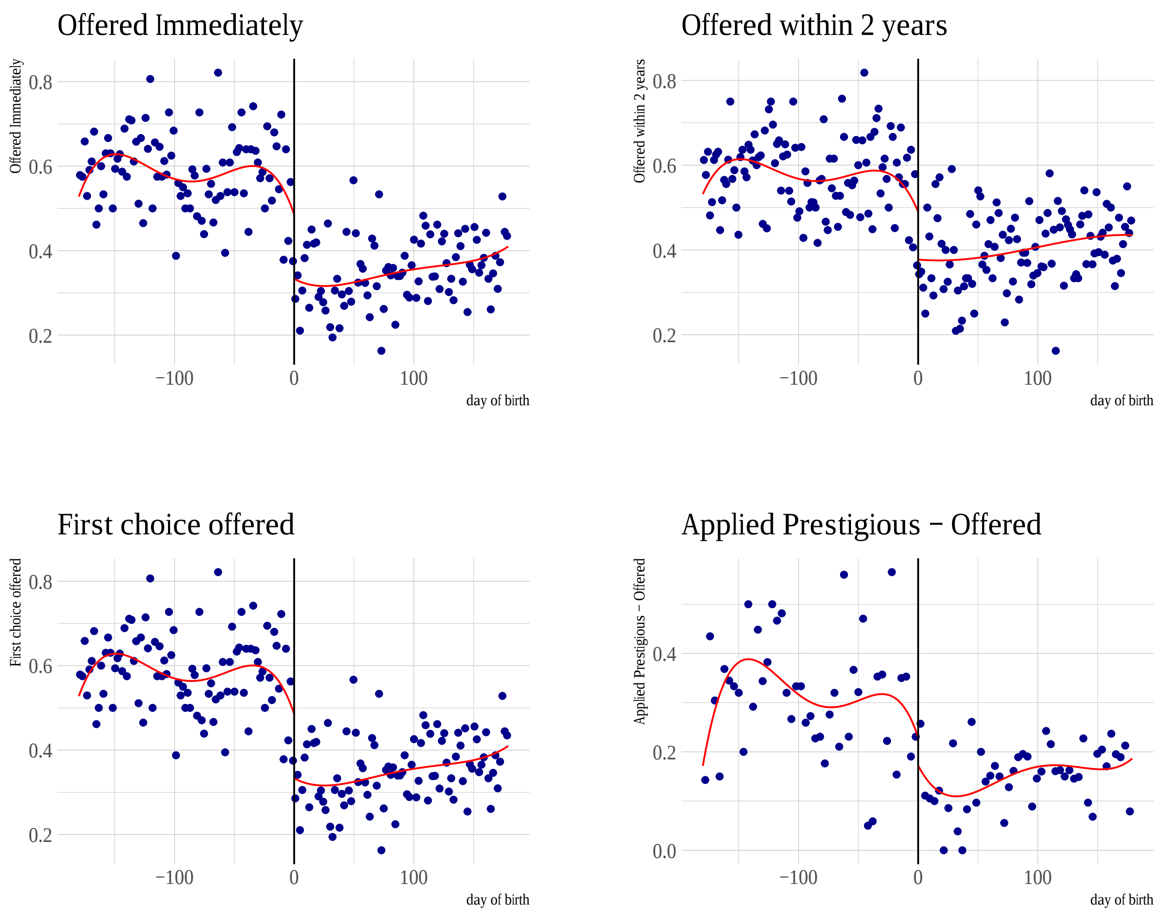


Figure 8
RD Estimates of Effects on Admission Outcomes

Notes: This figure plots binned means as detailed in Calonico et al. (2015) for the analysis sample of middle school students who graduated on time matched to students who graduated high school in the four-year reform. The outcomes, beginning from the left in the top panel are: Indicator for being offered admission conditional on applying to college immediately after graduation, Indicator for being offered admission conditional on applying to college within two years, Indicator for being offered admission to your first choice conditional on applying to college immediately after graduation, and indicator for being offered admission conditional on applying immediately to a "prestigious" program as a first choice. Prestigious is defined as a program with a cutoff above 44.

Table 9
RD ESTIMATES OF EFFECTS ON COLLEGE MARKET OUTCOMES

		Treatment: *Graduated in the Double Cohort*					
		No Aggregate Score Control			*Aggregate Score Control*		
		RDD	*OLS*	*2SLS*	*RDD*	*OLS*	*2SLS*
		(1)	(2)	(3)	(4)	(5)	(6)
First Stage							
Graduated in DC		0.727^{***}			0.705^{***}		
		(0.013)			(0.013)		
Outcomes							
Offered admission given applied immediately	0.59	-0.241^{***}	-0.330^{***}	-0.302^{***}	-0.134^{***}	-0.173^{***}	-0.167^{***}
		(0.038)	(0.019)	(0.028)	(0.031)	(0.016)	(0.024)
Offered admission given applied within 2 years	0.58	-0.181^{***}	-0.229^{***}	-0.233^{***}	-0.086^{**}	-0.095^{***}	-0.110^{***}
		(0.035)	(0.018)	(0.027)	(0.029)	(0.016)	(0.023)
Prestigious choice offered given applied immediately	0.32	-0.136^{**}	-0.205^{***}	-0.207^{***}	-0.091^{*}	-0.099^{***}	-0.125^{***}
		(0.052)	(0.027)	(0.041)	(0.045)	(0.024)	(0.037)
First choice offered given applied immediately	0.59	-0.241^{***}	-0.330^{***}	-0.302^{***}	-0.134^{***}	-0.173^{***}	-0.167^{***}
		(0.038)	(0.019)	(0.028)	(0.031)	(0.016)	(0.024)

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Notes: Parametric RD estimates of effects on graduating high school in an increased cohort size on final college market outcomes on admission chances. Cohort size is measured as a binary variable where an increased cohort size = 1 if graduated in the double cohort and 0 if graduated in a single cohort. A bandwidth of 180 days. The sample is restricted to students who completed grade 9 "on time" based on their date of birth and smooth progression and completed high school in the four-year cohorts. Columns (1) and (4): Reduced form estimates, including first stage estimate. Columns (2) and (5): OLS estimates. Columns (3) and (6): 2SLS estimates where graduating in the double cohort is instrumented by being born on or after January 1st, 1994. Columns (1) - (3) control for gender and (4) - (6) add controls for the aggregate score at the high school terminal examination. "Applied immediately" means applying to college in the same year of high school graduation. "Applied within 2 years" means applying to college within two years of graduating high school

V.4 Increased Cohort Size and Heterogeneity

Up to this point, I have documented adverse effects of graduating in an increased cohort size on short-term performance, students' decisions on the college education market, and their final admission outcomes. These effects may be exacerbated for females and economically vulnerable students and further affect outcomes such as those related to empowerment and inequality. It is thus perhaps pleasant to note that from reduced form estimates, graduating in the increased cohort does not differentially affect females and economically vulnerable students as reported in tables 10 to 13.

V.4.1 Gender

Tables 11 and 10 report these estimates with and without controlling for the aggregate score. The variable of interest is the interaction term, $after \times female$. It quantifies the additional effect of being born on or after the cutoff for females relative to males. Similar to the overall findings, from table 10, males perform worse, are less likely to apply immediately after graduation, are less selective in their first choices, and the lower likelihood of applying persists after two years, suggesting forgoing college. Females in the single cohorts are equally likely to apply to college immediately but are less likely to do so within two years of graduation when compared to males. This suggests the presence of factors that prevent females from continuing their education if they do not apply to college immediately without the effect of the increased cohort size.

V.4.2 Economically Vulnerable

Students more likely to reside in regions ranked in the top half of regions with high poverty are not differentially worse off from graduating in an increased cohort. These results, documented in tables 12 and 13, suggest the unintended effects of the two reforms did not worsen outcomes that could widen the inequality gap. The variable of interest in these tables is the interaction term $after \times \textit{below median SES}$. It quantifies the additional effect of being born on or after the cutoff for students residing in more economically vulnerable regions. The results in table 12

Table 10
RD ESTIMATES BY GENDER OF EFFECTS OF INCREASED COHORT SIZE

	Dependent Variables				
	Aggregate score	**Applied immediately**	**First choice cutoff above median**	**Offered immediately**	**Applied within 2 years**
after	-0.409^{***}	-0.067^{**}	-0.065^{**}	-0.261^{***}	-0.108^{***}
	(0.052)	(0.025)	(0.024)	(0.055)	(0.027)
female	-0.314^{***}	-0.050	-0.059^{*}	-0.052	-0.065^{*}
	(0.054)	(0.026)	(0.025)	(0.057)	(0.028)
after×female	0.108	-0.005	0.011	0.036	-0.008
	(0.069)	(0.033)	(0.032)	(0.076)	(0.035)
R^2	0.031	0.002	0.002	0.056	0.005
Num. obs.	28172	28433	28433	7163	28433

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Notes: Parametric RD heterogeneity estimates by gender of effects on graduating high school in an increased cohort size on outcomes defined in the column headers. Bandwidth is 180 days. Cohort size is measured as a binary variable where an increased cohort size = 1 if graduated in the double cohort and 0 if graduated in a single cohort. "after" is a binary variable = 1 for being born on or after the cutoff and 0 otherwise. "female" is a binary variable = 1 if a student is female and 0 otherwise. The interaction term measures the additional effect of being born on or after the cutoff on females. The running variable is interacted with the female dummy in all cases. The sample is restricted to students who completed grade 9 "on time" based on their date of birth and smooth progression and completed high school in the four-year cohorts. "Applied immediately" means applying to college in the same year of high school graduation. "Applied within 2 years" means applying to college within two years of graduating high school

Table 11
RD ESTIMATES BY GENDER OF EFFECTS OF INCREASED COHORT SIZE

	Dependent Variables			
	Applied immediately	**First choice cutoff above median**	**Offered immediately**	**Applied within 2 years**
after	0.016	0.006	-0.137^{**}	-0.012
	(0.024)	(0.023)	(0.043)	(0.025)
female	0.014	-0.003	0.006	0.009
	(0.025)	(0.024)	(0.044)	(0.026)
after×female	-0.032	-0.012	0.001	-0.038
	(0.031)	(0.030)	(0.061)	(0.032)
R^2	0.158	0.127	0.363	0.196
Num. obs.	28172	28172	7145	28172

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Notes: Parametric RD heterogeneity estimates by gender of effects on graduating high school in an increased cohort size on outcomes defined in the column headers. Bandwidth is 180 days. Cohort size is measured as a binary variable where an increased cohort size = 1 if graduated in the double cohort and 0 if graduated in a single cohort. "after" is a binary variable = 1 for being born on or after the cutoff and 0 otherwise. "female" is a binary variable = 1 if a student is female and 0 otherwise. The interaction term measures the additional effect of being born on or after the cutoff on females. The running variable is interacted with the female dummy in all cases and controls for the student's score at the high school terminal examination. The sample is restricted to students who completed grade 9 "on time" based on their date of birth and smooth progression and completed high school in the four-year cohorts. "Applied immediately" means applying to college in the same year of high school graduation. "Applied within 2 years" means applying to college within two years of graduating high school emphasize facts documented in the literature outside of the effect of graduating in the double cohort as seen in the variable *below median SES*. In single cohorts, lower SES students perform 32% of a standard deviation worse. They are also less likely to apply to college immediately and within two years and have reduced selectivity in their first choices. Their lower probability of college attendance and reduced selectivity is evident even after controlling for their ability in table 13.

Table 12
RD ESTIMATES BY SES OF EFFECTS OF INCREASED COHORT SIZE

	Dependent Variables				
	Aggregate score	**Applied immediately**	**First choice cutoff above median**	**Offered immediately**	**Applied within 2 years**
after	-0.337^{***}	-0.072^{***}	-0.062^{***}	-0.237^{***}	-0.105^{***}
	(0.037)	(0.018)	(0.017)	(0.040)	(0.019)
below median SES	-0.317^{***}	-0.183^{***}	-0.149^{***}	0.004	-0.145^{***}
	(0.084)	(0.030)	(0.029)	(0.129)	(0.037)
after× below median SES	0.134	0.091^{*}	0.079^{*}	-0.012	0.030
	(0.102)	(0.038)	(0.037)	(0.153)	(0.044)
R^2	0.026	0.015	0.013	0.057	0.016
Num. obs.	28172	28433	28433	7163	28433

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Notes: Parametric RD heterogeneity estimates by the socioeconomic status of the effects of graduating high school in an increased cohort size on outcomes defined in the column headers. Bandwidth is 180 days. Cohort size is measured as a binary variable where an increased cohort size = 1 if graduated in the double cohort and 0 if graduated in a single cohort. "after" is a binary variable = 1 for being born on or after the cutoff and 0 otherwise. Socioeconomic status is proxied by region of middle school and "below median SES" is a binary variable = 1 if a student's middle school is below the median regional poverty index and 0 otherwise. The interaction term measures the additional effect of being born on or after the cutoff on economically vulnerable students. The running variable is interacted with the SES measure in all cases. The sample is restricted to students who completed grade 9 "on time" based on their date of birth and smooth progression and completed high school in the four-year cohorts. "Applied immediately" means applying to college in the same year of high school graduation. "Applied within 2 years" means applying to college within two years of graduating high school

V.5 Robustness

To check the robustness of my results and identification concerns, I perform three main tests. First, I employ the difference in regression discontinuity design described in section IV. Next, to

Table 13
RD ESTIMATES BY SES OF EFFECTS OF INCREASED COHORT SIZE

	Dependent Variables			
	Applied immediately	**First choice cutoff above median**	**Offered immediately**	**Applied within 2 years**
after	-0.008	-0.007	-0.138^{***}	-0.030
	(0.017)	(0.016)	(0.032)	(0.017)
below median SES	-0.123^{***}	-0.098^{***}	-0.013	-0.073^{*}
	(0.029)	(0.028)	(0.098)	(0.034)
after ×	0.065	0.057	0.030	-0.001
below median SES	(0.036)	(0.035)	(0.127)	(0.041)
R^2	0.164	0.132	0.363	0.201
Num. obs.	28172	28172	7145	28172

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Notes: Parametric RD heterogeneity estimates by the socioeconomic status of the effects of graduating high school in an increased cohort size on outcomes defined in the column headers. Bandwidth is 180 days. Cohort size is measured as a binary variable where an increased cohort size = 1 if graduated in the double cohort and 0 if graduated in a single cohort. "after" is a binary variable = 1 for being born on or after the cutoff and 0 otherwise. Socioeconomic status is proxied by region of middle school and "below median SES" is a binary variable = 1 if a student's middle school is below the median regional poverty index and 0 otherwise. The interaction term measures the additional effect of being born on or after the cutoff on economically vulnerable students. The running variable is interacted with the SES measure in all cases. The sample is restricted to students who completed grade 9 "on time" based on their date of birth and smooth progression and completed high school in the four-year cohorts. "Applied immediately" means applying to college in the same year of high school graduation. "Applied within 2 years" means applying to college within two years of graduating high school examine year on year comparability of the examination at the end of high school, I review aggregate performance in two other Anglophone countries in ECOWAS. Lastly, I vary the bandwidths used in my results and the specifications. Tests 1 and 2 are discussed below and 3 is presented in the appendix.

Results from the difference in regression discontinuity show no significant effect on outcomes of relative age or any other difference from being born on or after January 1st beyond changing your graduation cohort. In table B.1, panel A replicates the results from the standard RD for the treatment year, showing the adverse effects of being born $after$. In panel B, using a control year of 01-01-1993, there is no differential effect across all outcomes except for the likelihood of being offered admission. This is attributable to the fact that there is no pure control cutoff because of the spillover across graduation years across each cutoff coupled with the short implementation period of reforms. 01-01-1993 has a small but significant jump of 8% for graduating in the double cohort. The effect of graduating in the double cohort after excluding any impact of relative age and any other differences are reflected in $after \times treatment$ in panel C. These are qualitatively similar to the main results and should be considered a lower bound.

The West African Examination Council, which administers the sub-regional high school terminal examination, posits that exam difficulty is comparable yearly. I consider the performance trend of students in Nigeria and the Gambia who also participated in the WASSCE in this period. Figure A.6 shows the proportion of students [that obtained a credit score or above in Mathematics. At the introduction of the four-year reform in 2011 and 2012, all three countries exhibited a similar trend. In 2013 however, when Ghana had the increased cohort, while Nigeria and Gambia recorded an increase in performance, performance in Ghana fell. This additional evidence supports that the decrease in performance identified from graduating in the increased cohort year was not because the examination in that year was more challenging.

V.6 Discussion

My findings indicate that graduating in an increased cohort size adversely affected short-term performance and the likelihood of college attendance. College educational attainment was reduced not only because students were less likely to apply, but even when they did, supply-side constraints barred them from receiving admission offers. In this section, I explore possible mechanisms, generalization of the college-related outcomes in the University of Ghana to other public and private universities and highlight areas for further work.

Graduating high school in an increased cohort size resulted in a significant reduction in students' performance at the terminal examination, even without much change in school size. Further analysis showed a differential effect by duration in high school. Students in the double cohort in the four-year reform were adversely affected by the increased cohort size, whereas those in the three-year reform were positively affected. Two potential channels can reconcile this puzzle. First, as generally noted in the class and school size literature, size matters because without an increase in school inputs, resources per student decrease. Lavy (2015) presents that schools in developing countries are more likely to be burdened by resource constraints and anecdotal evidence in Ghana suggests high schools allocate more resources to the graduating cohort in preparation for the terminal examination. This could be because the combination of already scarce resources and the high-stakes nature of the terminal examination makes it more prudent for schools to allocate their resources differentially. Congestion due to the double cohort with relatively no change in overall school crowding would imply fewer resources per student, leading to a fall in performance.

The second channel is the role of effort for students in the double cohort who feel disadvantaged because they have fewer years. The combination of students with different duration in the double cohort may have caused students with fewer years to exert more effort if they felt disadvantaged competing with the students with the extra year. These two channels would mean that for all students in the double cohort, performance would fall because of fewer resources, and for the students with one less year, the extra effort allows them to perform better than their counterparts with three years in single cohorts. This increased effort is, however, not enough to compensate for the extra year in the four-year reform. The fact that performance in the three-year double cohort was significantly better than the three-year single cohort could imply that within the double cohort, schools allocated more resources to the three-year students so that the negative impact from reduced resources in the increased cohort size was less than the four-year double cohort students. I do not have data on the allocation of high school inputs and student effort over this period, but further investigation into these mechanisms is the focus of future work.

My findings show students are less likely to obtain a college degree for two reasons. First, they delay applying if they graduate in an increased cohort. Secondly, even when they apply and are equally able, colleges cannot offer them admission because of severe supply barriers. A potential mechanism to explain why students reduce their likelihood of applying to college is an increase in their expectations of competitiveness. A double cohort graduating high school, all things being equal, would mean an influx into the college market, thus increasing demand for college education. Without a proportional increase in the supply of college seats, the chances of being offered admission should be lower. The fact that students reduced the selectivity of their first choices and were still less likely to apply to college even after considering their performance suggests students were aware of this increased competition. Although I see these results mainly in the cohort analysis, it is worth noting that the RD sample is a subset of students who already had a high probability of obtaining a college degree and are less likely to be on the margin.

My findings on college-related outcomes draw on data from one public university. Although the University of Ghana is large and accounts for at least 19% of all enrollment in public universities, a reasonable question is whether these results can be generalized to other public and private universities. Although I am unable to conclusively state that the magnitudes would be similar, the left panel in figure A.5 shows a trend in all public universities applications and enrollment that mirrors the trends in the University of Ghana as shown in figure 2. Considering private universities during this period, the right panel in A.5 shows that, unlike public universities, private ones responded to the increased demand but there were still severe supply-side constraints barring them from absorbing the increased demand. These together suggest that my results can reasonably reflect the circumstances of other public universities but to a less extent private ones.

VI Conclusion

In this paper, using a cohort analysis and a regression discontinuity design, I show that graduating in a high school cohort with an increased size has adverse effects on short-term performance and the chances of obtaining a college degree. The latter is driven by students' decision to not apply to college and the fact that colleges are unwilling or unable to absorb the increased demand even when they do. On a positive note, females and economically vulnerable students are not differentially affected. These findings are identified in a natural experiment in Ghana created by two reforms that first added a year to the duration of high school and removed the extra year after three years of implementation, resulting in two cohorts graduating high school simultaneously in 2013.

My findings primarily imply that students who graduate in a double cohort are less prepared when they graduate. Further, they not only postpone college, but they also forgo it altogether. The reduced human capital development and lower educational attainment in the increased cohort have implications for their labor market outcomes. In a developing country like Ghana, where unemployment rates are high, this reduced preparedness for the labor market could significantly affect their outcomes. The literature on the effect of increased cohort size on the labor market generally shows adverse outcomes and this reduced preparedness may exacerbate that.

In relation to policy, policymakers must be mindful of the unintended consequences of initiated reforms. Particularly in developing countries, education structures are still undergoing restructuring, leading to many new reforms. The need to holistically assess these reforms before implementation is critical, to identify any unintended effects and implement safeguards to mitigate them.

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Appendix

1. Appendix A - FIGURES

2. Appendix B - TABLES

3. Appendix C - DATA AND OUTCOMES

Appendix A - FIGURES

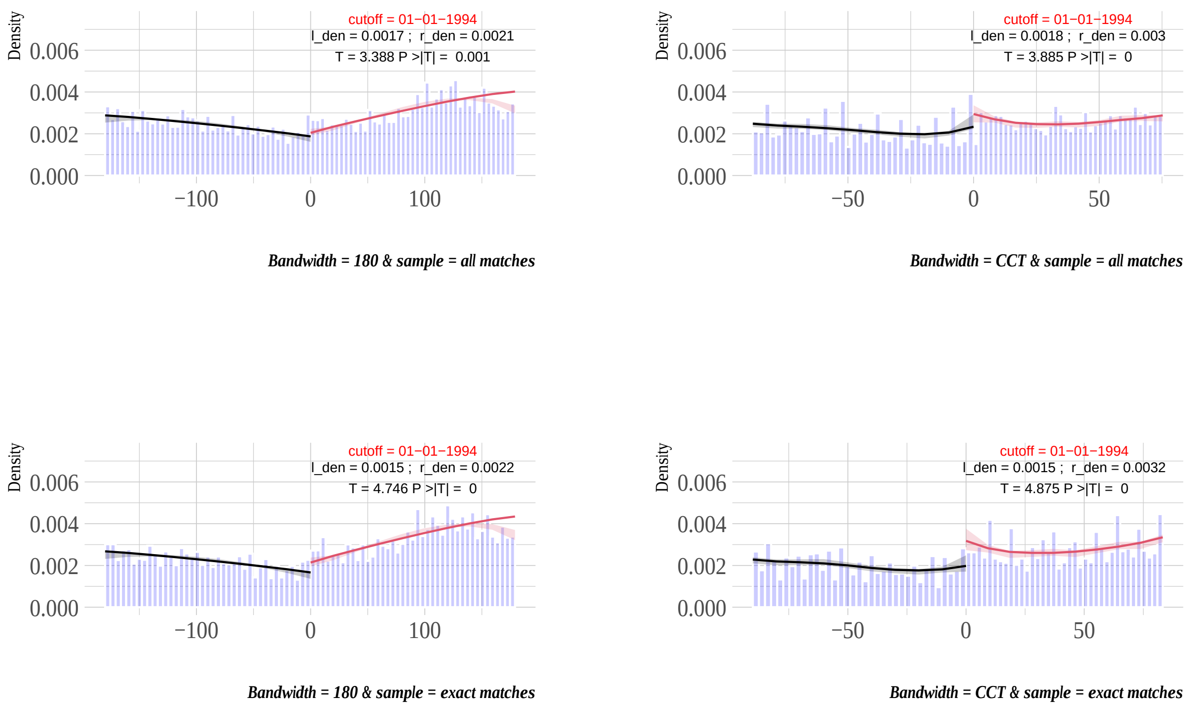

Figure A.1
McCrary Density Test

Notes: This figure shows the McCrary Density Manipulation Test around the treatment cutoff year for the full sample using approximate matching in the top panel and the sample restricted to exact matches in the bottom. Results from a bandwidth of 180 are shown on the left, with results using optimal bandwidths as specified by Calonico et al. (2014) are shown on the right.

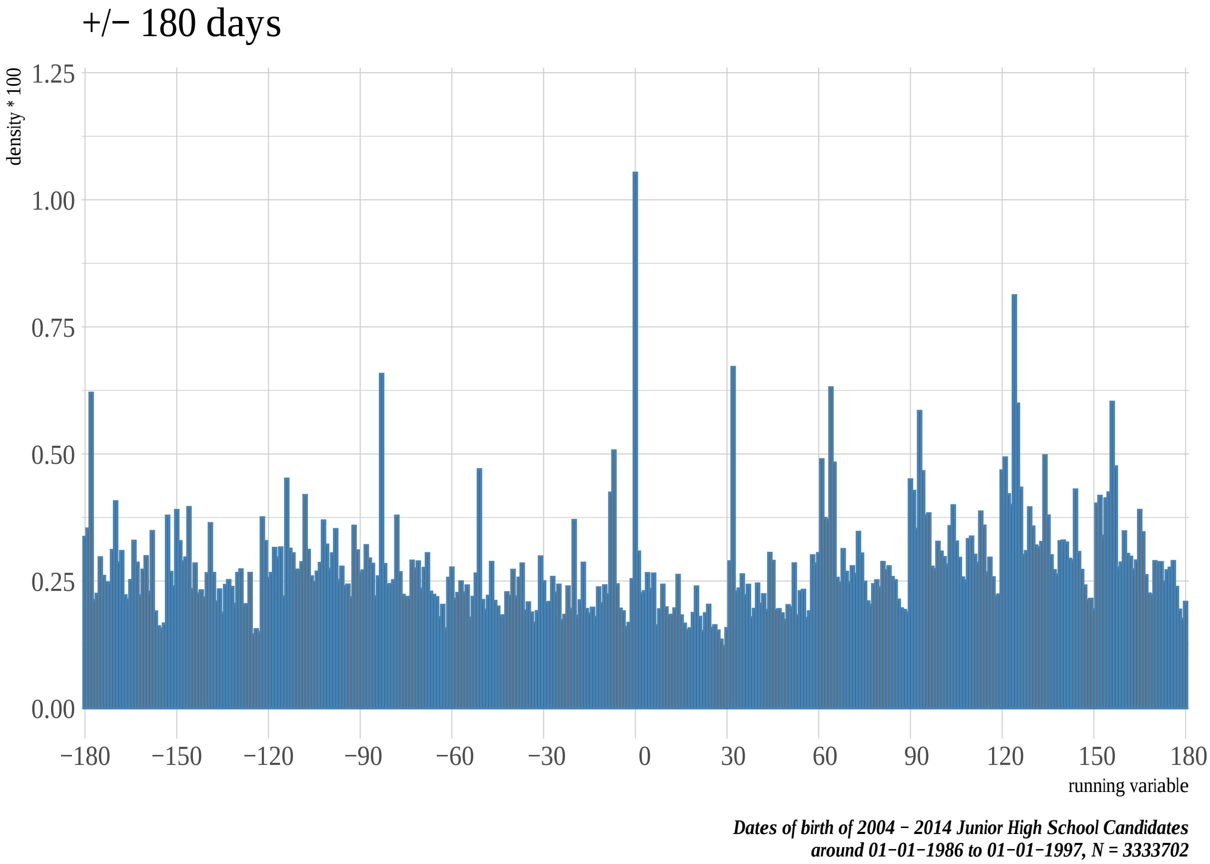

Figure A.2
Stacked Histogram of Dates of Birth

Notes: This figure shows the stacked histogram of dates of birth for all middle school graduates from 2004 to 2014, born between July 1985 and June 1997. January 1st of each year over this period is normalized to 0, and dates of birth 180 days before and after are considered. There is no overlap of observations.

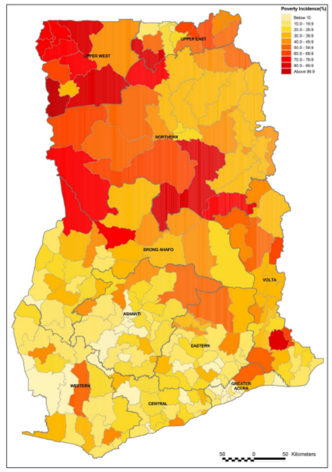

Figure A.3
Poverty Incidence by Administrative Regions in Ghana

Notes: Source: 2015 Ghana Poverty Mapping, Ghana Statistical Services; Data from the 2010 population census and GLSS 6 - Ghana Living Standard Survey in 2012/2013 is used. Poverty Incidence maps the proportion of the population living below the national poverty line of GHS 1,314 $\approx$ USD 919. (Using 2010 average Interbank FX mid-rates obtained from the Bank of Ghana)

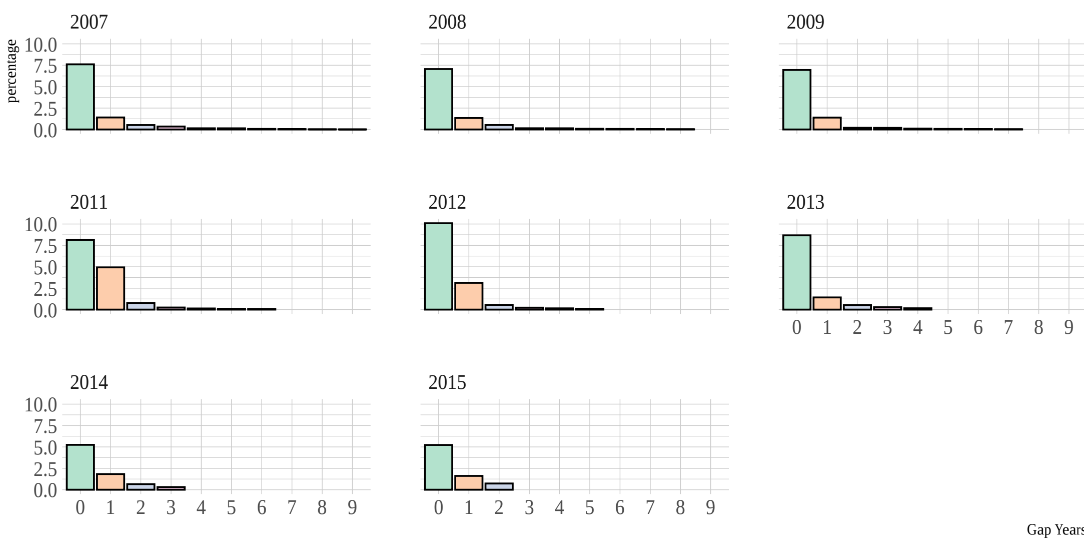

Figure A.4
Number of Gap Years Before College

Notes: This figure shows the percentage of all high school(HS) students who graduated from 2007 to 2015 who ever applied to the University of Ghana between 2008 and 2017. There was no high school terminal examination in 2010. 2007 - 2009 (3 years in HS) are pre-reform year, 2011 - 2012 are the reform years (4 years in HS), and reversion resulted in a double cohort in 2013. 50% with 4 years in SHS) and 2014 - 2015 are post-reform years (3 years in HS)

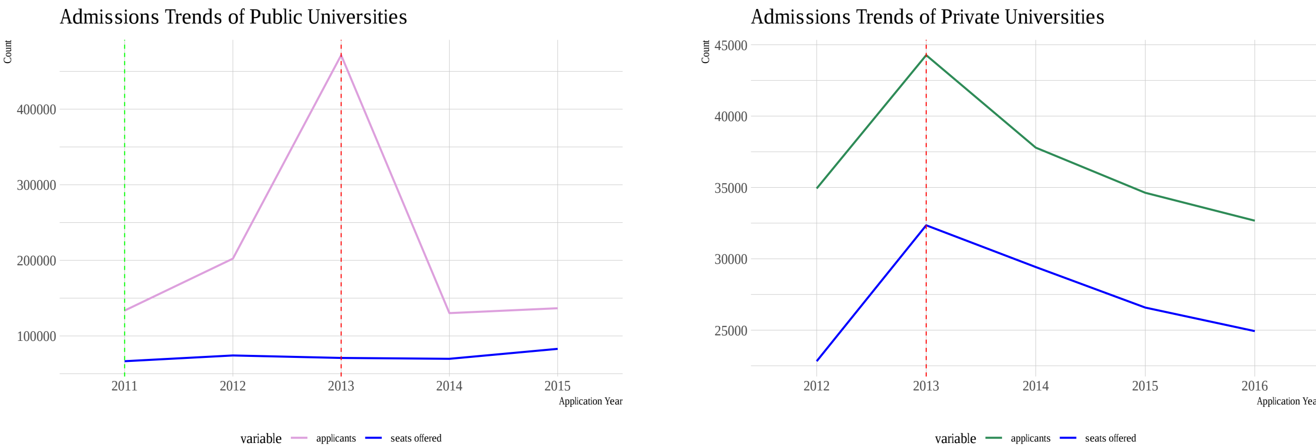

Figure A.5
Admission Trends in Public and Private Universities

Notes: Data Source: Statistical Report, National Council for Tertiary Education, Ghana. This figure shows the number of applicants to public (left panel) and private (right panel) universities. There are 9 public universities accounting for about 58% of total students in tertiary. By 2016, there were 74 accredited private tertiary institutions. Values may include applicants to all levels of tertiary - bachelors, short-cylce, masters. or doctorals and their equivalents. The dashed green vertical line marks the year the first cohort in the four-year reform graduated and the dashed red line marks the year the double cohort graduated in both panels.

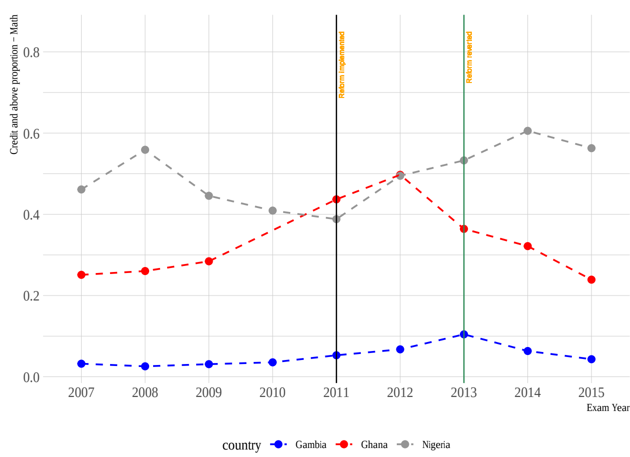

Figure A.6
West Africa Sub-Regional Performance: Mathematics

*Notes:*This figure shows the proportion of high school graduates with a credit or higher score in mathematics. The double cohort year and the year the first cohort from the four-year reform graduated are marked by vertical lines.

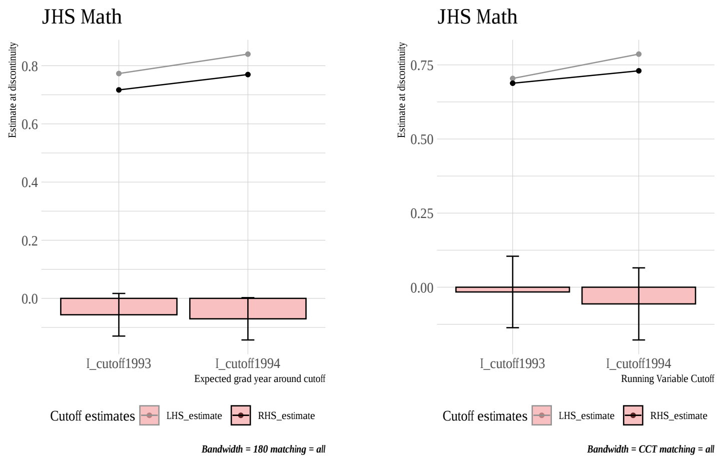

Figure A.7
Pre-treatment Mathematics Score

*Notes:*This figure shows the pre-treatment mathematics score at the end of middle school for 01-01-1994 the treatment cutoff and 01-01-1993, the control cutoff. Bar charts show the jump at the cutoff and the line graphs show the mathematics score on the left and right-hand side of the cutoff. The left panel shows a 180 bandwidth and the right panel shows the optimal bandwidth proposed by Calonico et al. (2014).

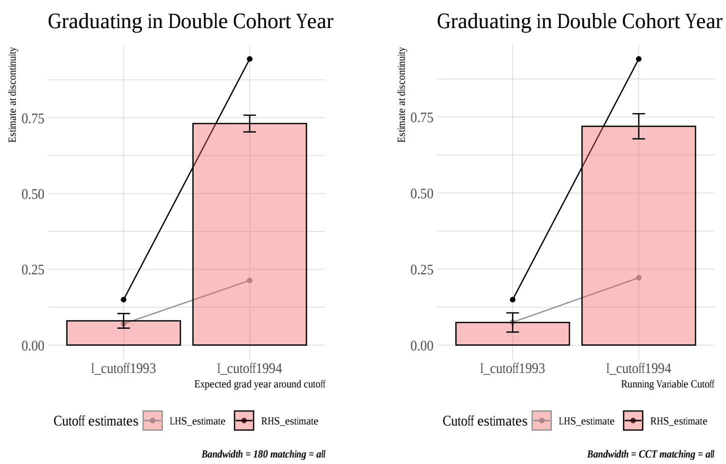

Figure A.8
First-stage Comparison: Treatment and Control Cutoff

*Notes:*This figure shows the first stage for 01-01-1994 the treatment cutoff and 01-01-1993, the control cutoff. The dependent variable is an indicator for graduating high school in the double cohort year. Bar charts show the jump at the cutoff and the line graphs show the probability of graduating in the double cohort on the left and right-hand side of the cutoff. The left panel shows a 180 bandwidth and the right panel shows the optimal bandwidth proposed by Calonico et al. (2014).

Appendix B - TABLES

Table B.1
DIFFERENCE IN RD ESTIMATES OF EFFECTS OF INCREASED COHORT SIZE

	Dependent Variables				
	Aggregate Score	**Applied Im.**	**First choice cutoff above median**	**Offered Im.**	**Applied within 2 yrs**
Panel A- Treatment Year - 1994					
after	-0.347^{***}	-0.068^{***}	-0.057^{***}	-0.241^{***}	-0.110^{***}
	(0.034)	(0.016)	(0.016)	(0.038)	(0.017)
Num. obs.	28172	28433	28433	7163	28433
R^2	0.031	0.002	0.001	0.055	0.004
Panel B- Control Year - 1993					
after	0.027	-0.005	0.006	-0.11^{**}	-0.026
	(0.034)	(0.015)	(0.014)	(0.042)	(0.016)
Num. obs.	30780	31146	31146	6418	31146
R^2	0.018	0.005	0.005	0.012	0.004
Panel C- Both Years					
after	0.027	-0.005	0.006	-0.11^{**}	-0.026
	(0.034)	(0.015)	(0.014)	(0.042)	(0.016)
after×treatment	-0.374^{***}	-0.062^{**}	-0.062^{**}	-0.129^{*}	-0.085^{***}
	(0.048)	(0.022)	(0.021)	(0.056)	(0.024)
Num. obs.	58952	59579	59579	13581	59579
R^2	0.024	0.006	0.006	0.055	0.005

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Notes: Reduced form estimates in a parametric difference in RD design of the effect of graduating high school in an increased cohort size on outcomes defined in the column headers. Bandwidth is 180 days. Cohort size is measured as a binary variable where an increased cohort size = 1 if graduated in the double cohort and 0 if graduated in a single cohort. Panel A shows the results for the cutoff 01-01-1994, the treatment cutoff where marginal students on the right are more likely to graduate in an increased cohort size. Panel B shows the results for the cutoff 01-01-1993, the control cutoff where the discontinuity in the likelihood of graduating in an increased cohort size is positive but minimal. "after" is a binary variable = 1 for being born on or after the cutoff and 0 otherwise. Panel C combines both cutoffs and "after × treatment" shows the difference in treatment discontinuity beyond the discontinuity in the control cutoff. These results should be seen as a lower bound as the control cutoff has a small but significant discontinuity for graduating in an increased cohort. The sample is restricted to students who completed grade 9 "on time" based on their date of birth and smooth progression and completed high school in the four-year reform. "Applied Im" means applying to college in the same year of high school graduation. "Offered Im" means offered admission conditional on applying to college in the same year of high school graduation."Applied within 2 years" means applying to college within two years of graduating high school.

Appendix C - DATA AND OUTCOMES

Computation and Re-calibration of High Score Aggregate Score

The high school aggregate is a composite score computed from six subjects from the WASSCE, the high school terminal examination. This score is the main measure of ability considered for college admissions. I document below how it is computed and how I re-calibrate it for my analysis.

Students sit for eight or seven subjects in the WASSCE, depending on their school and high school field specialization. Some examples of these specializations are science, general arts, business, and visual arts. Four of these subjects are core subjects for every student - core Mathematics, core English, Integrate Science, and Social Studies - and the remaining are electives. In each subject, a letter grade ranging from the highest, A1 then B2, B3, C4, C5, C6, D7, E8, and the lowest, F9 can be awarded. For students who specialize in Science in high school, their aggregate score is composed of their scores in three core subjects - Mathematics, English, and Integrated Science- and their three elective subjects with the highest grades. For non-Science students, their aggregate score is composed of their scores in three core subjects - Mathematics, English, and Social Studies - and their three elective subjects with the highest grades.

The aggregate score then equally weights grades in these six subjects by summing the number attached to the letter grades. For example, a science student with A1 in core mathematics, B2 in core English, B3 in Integrated Science, C4 in Chemistry, C5 in Physics and C6 in Elective Mathematics will have an aggregate score of $21 = 1 + 2 + 3 + 4 + 5 + 6$. This implies highest performance possible will have an aggregate score of 6 and the lowest possible performance will have an aggregate score of 54.

For an intuitive understanding of scores so that a higher score means higher performance, I re-calibrate the aggregate score and normalize the lowest performance to a score of 0 so that the highest performance has a score of 48. Formally, the transformation is given by the function, f:

$$f : \hat{Agg} = 54 - Agg$$

where $\hat{Agg}$ is the re-calibrated aggregate score used in the analysis and Agg is the raw aggregate score computed from grades on the WASSCE.