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TEACHERS COLLEGE, COLUMBIA UNIVERSITY

# The Impact of Dual Enrollment on College Application Choice and Admission Success

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**Abstract**

Dual enrollment (DE) is one of the fastest growing programs that support the high school-to-college transition. Yet, there is limited empirical evidence about its impact on either students' college application choices or admission outcomes. Using a fuzzy regression discontinuity approach and data from two cohorts of ninth-grade students in one anonymous state, we found that taking DE credits increased the total number of colleges students applied to and the likelihood of applying to any moderately or highly selective in-state four-year institution. Attempting DE credits also increased the total number of in-state four-year colleges a student got admitted to and the probability of being admitted to a highly selective in-state four-year college. Heterogeneous analysis further indicates that the gains were primarily driven by Black students.

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## 1. Introduction

Improving college access and facilitating better student-college matches continues to capture the attention of researchers and policymakers. Discussion of these issues stems in part from the growing evidence of the phenomenon of undermatching, whereby many well-qualified students—especially those from historically underserved groups—are not enrolled at selective colleges aligned with their academic capabilities (e.g., Baker, 2018; Dillon & Smith, 2017; Hill et al., 2005; Hoxby & Turner, 2013). White students are overrepresented at selective public colleges, representing 64% of freshman enrollment at these institutions despite being 54% of the college-age population. Meanwhile, Black and Hispanic students are underrepresented and only make up 7% and 12% of freshman enrollment respectively at selective public colleges (Carnevale et al., 2018).

While multiple factors may contribute to these racial/ethnic gaps in college enrollment decisions, one driving factor that has drawn increasing public attention is that high-achieving students from low-income families are substantially less likely to apply to selective institutions than high-income students with similar levels of academic preparation. For example, based on nationwide data from the high school graduating class of 2008, Hoxby and Avery (2013) found that the majority of high-achieving, low-income students do not apply to any selective colleges despite being well qualified according to admission criteria. The suboptimal college-enrollment choices among students from underrepresented groups are troubling from an equity perspective, given the mounting evidence of the benefits of attending well resourced, selective institutions for both college completion rates and labor market outcomes (Zimmerman, 2014; Black et al., 2020; Cohodes & Goodman, 2014; Hoekstra, 2009; Bleemer, 2019). In addition, growing evidence suggests that students from underrepresented groups (Black students in particular) seem to benefit more from attending selective colleges than their White peers (Black et al., 2020; Dale & Krueger, 2011; Hoekstra, 2009).

College acceleration programs, such as dual enrollment (DE) programs, are one way to boost college access and success in college, especially for students typically underrepresented in higher education (e.g., Karp, 2012; An & Taylor, 2019). DE programs allow high school students to experience college-level courses and accumulate college credits while in high school. Advocates of DE programs are also optimistic about their potential to enhance students' academic self-efficacy in applying to college and to offer an admission boost by helping students build an advanced course portfolio (Clinedinst et al., 2011; Hugo, 2001). DE is one of the fastest growing programs that support the high school-to-college transition and has increased in nearly every state over the past decade (Taie & Lewis, 2020; Marken et al., 2013). Yet, despite optimism that DE programs promote college application and admission success, there is limited empirical evidence of these programs' impact on either students' college application choices or their admission outcomes.

This paper addresses this research gap using a unique dataset that includes high school students' college application and admission data from an unnamed large American state. Drawing on data from two cohorts of ninth-grade students (the classes of 2007 and 2012), we examine the effect of taking DE credits on the number of public colleges students applied and got admitted to and the selectivity of these colleges within the state. To address student sorting into DE programs, we use a fuzzy regression discontinuity (FRD) approach that exploits the grade point average (GPA) cutoff for DE eligibility. Our results indicate that while taking DE credits did not influence the probability of applying to at least one in-state four-year college, it increased the total number of colleges a student applied to and the likelihood of applying to any moderately or highly selective in-state four-year institution. In terms of admission outcomes, taking DE credits increased the total number of in-state four-year colleges a student got admitted to and the probability of being admitted to a highly selective in-state four-year college. Heterogeneous analysis by race/ethnicity further indicates that the impacts on college application and admission outcomes were primarily driven by Black students.

Our analysis contributes to the small but growing literature that examines the causal effects of college acceleration programs on student postsecondary education choices and enrollment outcomes. Earlier studies using quasi-experimental designs (Allen & Dadgar, 2012; Miller et al., 2018; Speroni, 2011) primarily focused on postsecondary enrollment and performance outcomes. Overall, these studies found that DE participation had null to minimal positive impacts on the probability of enrollment in a postsecondary institution and on performance conditional on enrollment. However, a recent study that used a randomized controlled trial and differentiated between two-year and four-year institutions found that while taking DE math courses had null impact on overall rates of college enrollment, it induced students to choose four-year over two-year colleges (Hemelt et al., 2020). This finding highlights the possibility that DE participation may influence students' college application choices. We draw on this line of work and contribute to it by directly examining the impacts of DE participation on students' college application choices and admission outcomes.

## 2. Theoretical Framework and Related Research

The theoretical literature on college matching as a market equilibrium problem has furnished a number of key elements that could influence students' college application portfolio choices, such as prior academic performance, preferences for colleges, application costs, and information friction that creates uncertainty for both students and colleges (e.g., Chade et al., 2014; Fu, 2014; Ali & Shorrer, 2021). On the one hand, students, who have heterogeneous academic skills and preferences for colleges that are unknown to the colleges, make college application decisions subject to uncertainties about application and tuition costs. On the other hand, colleges, observing noisy measures of student prior academic performance and fit, compete for better students by setting admissions standards and offering admission to sets of students.

Students face a nontrivial portfolio choice: how many and which, if any, colleges to apply to. Moreover, applications are costly, and colleges' evaluations of students' applications and admission chances are unknown to students. Besides completing admission tests and applications, students invest time and effort gathering and processing information and preparing application materials. Students may also sustain psychic costs, such as the anxiety associated with waiting for admission results (Fu, 2014) and calculating future college costs. Even the highest achieving applicants face admission uncertainty (Avery & Hoxby, 2004), so it is not surprising that most applicants construct thoughtful portfolios that include "safety," "match," and "reach" colleges. Colleges also face information friction and market uncertainties as they seek to fill their freshman classes with the best students possible and can only observe noisy measures of student academic performance and fit, such as student test scores, high school transcripts, DE participation, extracurricular activities, and essays.

Earning college credit while still in high school, which is typically accomplished either through DE or Advance Placement (AP) programs, may reduce application costs and uncertainty in the admission process and consequently change both students' application behavior and admission outcomes in several ways. First, successful learning experiences in college acceleration programs may increase students' college aspirations and expectations, promote academic self-efficacy to succeed in future college work, and help students build academic skills and confidence. These may in turn reduce students' anxiety and uncertainty about applying to colleges and increase their confidence about being admitted to a selective college. In addition, college acceleration programs allow students to accumulate college credits in high school and enable them to skip introductory courses or required general-education courses in college. These financial benefits help reduce the time to degree and the costs of college, which may alleviate the psychic costs associated with attending more expensive colleges. Second, DE and AP participation may also favorably influence admission outcomes by signaling students' college readiness and academic aspirations to selective colleges. Finally, drawing from Ali and Shorrer (2021), a decrease in application costs may encourage students to expand their range of college choices by including more selective colleges.

Despite these theoretical hypotheses, due to limited data linking AP/DE program participation with college application and admission records, little empirical evidence exists regarding the impact of earning college credits in high school on application behavior. Using records from the National Student Clearinghouse (NSC), the College Board, and ACT, Inc., Conger et al. (2020) and Smith et al. (2017) have provided the only empirical evidence of the impact of AP exam scores and coursetaking on students' college application choice and enrollment. Conger et al. (2020) experimentally evaluated the average impact of taking an AP science course and found no significant effects of taking an AP course and achieving higher AP exam scores on students' application choices, college plans, and likelihood of admission to selective colleges based on student surveys. Smith et al. (2017) exploited discontinuities in six of the most commonly taken

AP exams and relied on the set of colleges where students sent SAT scores to determine whether college application behavior was altered by AP exam scores.

While both DE and AP are college acceleration programs, they each have distinct features. Unlike AP programs, which offer high school courses taught to college-level academic standards, DE provides an opportunity for students to take actual college courses and is likely to attract different types of students. Accordingly, it is unclear whether the evidence about the impact of AP coursetaking on college application choices and admission outcomes to selective colleges may be applicable to DE participation. Perhaps the most relevant DE study is by Hemelt et al. (2020), who conducted a randomized controlled trial to estimate the effect of dual-credit math coursework on college enrollment and selectivity. The authors found that taking a DE math course induced some students, particularly middle-achieving students, to choose four-year instead of two-year colleges. These are important findings, as they highlight the possibility that DE participation may encourage students to apply to more selective colleges, increase their chance of being admitted to a selective college, or both. Yet, without application and admission data, Hemelt et al. (2020) were not able to provide insights into these mechanisms.

Our study builds on the current literature by examining the impact of DE participation on students' college application choices and admission outcomes separately. To do so, we use a unique dataset that links students' DE participation with their application and admission outcomes to all in-state public colleges, and we exploit exogenous variations in the eligibility for DE participation through a regression discontinuity design. Results from our study may help policymakers achieve a more comprehensive understanding of the benefits of DE programs overall and for different subgroups of students, thus enabling them to make more informed decisions about DE expansion and student support.

## 3. Data and Setting

### 3.1 State Context in Dual Enrollment

This study was conducted at an anonymous public state postsecondary system that consists of over 25 two-year and four-year colleges. Approximately two thirds of all public high school graduates in the state begin college at one of the in-state public colleges. Among the 10+ public four-year colleges, 25% are ranked as highly selective, 58% as moderately selective, and 17% as inclusive institutions according to the Carnegie Classification of Institutions of Higher Education.[1] These statistics reflect the distribution of selectivity across all four-year institutions nationally.

The state currently operates one of the largest DE programs in the nation. According to the state's official records, the number of DE students doubled between 2010 and 2019, culminating in approximately 70,000 students in the academic year 2019-2020. All public schools, charter schools, private schools, and home education are allowed to participate in DE, as long as there is an articulation agreement with the participating postsecondary institution. The state covers tuition, registration, and laboratory fees for all DE courses. Students enrolled at public high schools are also eligible to receive any DE instructional materials free of charge.

In general, students in grades 6–12 are required to have a minimum cumulative GPA of 3.0 to be eligible for academic DE courses.[2] However, the cutoff score for a particular course may vary across districts, as well as across postsecondary institutions. The majority of DE students in this state take college-level courses that are intended to fulfill the requirement of an associate or bachelor's degree.[3] More than 80% of the DE

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[1] The Carnegie Undergraduate Profile Classification describes the undergraduate students of a certain higher education institution based on three characteristics: (1) proportion of full-time versus part-time students, (2) selectivity of first-time freshman students, and (3) the rate of transfer from a different institution. Our selectivity index is based on the second characteristic, according to which highly selective, moderately selective, and inclusive institutions are defined as more selective, selective, and inclusive, respectively. See The Carnegie Classification of Institutions of Higher Education (n.d.).

[2] Some of the institutions also require meeting the cutoff of college placement test scores. However, among students who had a valid college placement test score and also met the GPA cutoff requirement, over 90% also met placement test requirements. Thus, we primarily drew on the GPA cutoff requirements when implementing the regression discontinuity design analyses.

[3] College credit earned through the DE program can be transferred to any public colleges or universities in this state. However, if the DE credits were not earned at the receiving institutions, the receiving institution may decide at their discretion whether the credits can be used toward general education, prerequisite, or degree programs.

students in the state's community colleges take freshman- and sophomore-level academic courses, and the rest are enrolled in career-technical and apprenticeship coursework. The two most popular courses among DE students are College Algebra and Freshman Composition, which account for one third of all DE course enrollments.[4]

It is important to clarify that our study is focused on DE at community colleges and does not look at DE at four-year colleges for two reasons. First, our state only started offering DE at four-year colleges after 2010. We therefore have data from only one cohort that had access to DE at four-year colleges, which may significantly limit our estimation power. Second, none of the students within our bandwidth took a DE course at a four-year college. Most four-year colleges require a minimum unweighted GPA of 3.6, which is substantially higher than the DE enrollment requirements set by community colleges (3.0 GPA).

### 3.2 Data and Sample Description

Our data contain five years of administrative records for two cohorts of ninth graders enrolled at any public high schools in this state (the 2007 and 2012 cohorts, who entered ninth grade in fall 2007 and 2012, respectively), for a total of roughly 500,000 students. The dataset consists of students' demographic information and detailed high school transcripts, which include course enrollment and performance in DE programs from ninth through twelfth grade. One notable feature of this dataset is that it also includes each student's college application portfolio, admission outcomes, and enrollment records for two-year and four-year in-state public colleges. This unique piece of information enables us to examine whether DE credits influence students' college choice portfolio and admission success.

One limitation of the data is that the application and enrollment information only concerns public state institutions. In other words, if a student applied to and enrolled in an in-state private institution or out-of-state institution, such information would be missing from our data. This creates a greater challenge for determining college enrollment outcomes than for determining college application outcomes because students

[4] Freshman Composition and College Algebra represent 21% and 9% of all unique DE course enrollment, respectively.

typically apply to multiple colleges in their college choice portfolio due to the uncertainty of the application process. Accordingly, students' in-state college choices could at least partially reflect their overall college portfolio choices. Indeed, current studies on students' college application choices indicate that students who apply to private or out-of-state colleges tend to include in-state public colleges of similar selectivity in their college choice portfolio (Fu, 2014). We therefore focus on students' college application and admission outcomes and do not consider enrollment outcomes in this paper.

Our analytical sample contains 115,413 students, 18.4% of whom dual-enrolled in grades 11 (8.2%) or 12 (15.6%) and 5.3% of whom dual-enrolled in both grades.[5] Between the two cohorts, the DE participation rate was higher among the 2012 cohort (21.4%) than the 2007 cohort (15.5%). Table 1 presents the descriptive statistics on the demographic characteristics for the full sample of students in our analytical sample (column 1) and also breaks down these numbers by DE program participation (columns 2–3). Compared with non-DE students, DE students were slightly more likely to be female (57%) and White (56%) and less likely to receive free or reduced-price lunch (37%). Both DE and non-DE students in our sample came from schools with fairly similar characteristics.

### 3.3 Outcome Measures

Our analysis focuses on two categories of outcome measures: students' college application choices and admission outcomes. The former includes measures of whether a student ever applied to college and the number of four-year colleges students applied to. To examine whether DE encourages students to apply to more selective colleges, we further break down the in-state four-year colleges into three categories by selectivity based on the Carnegie Classification of Institutions of Higher Education: highly selective, moderately selective, and non-selective.

Like the application measures, there are four specific measures for the admission outcomes: the total number of any in-state four-year college a student got admitted to, the probability of being admitted to at least one four-year college (versus being admitted to none), the probability of being admitted to at least one moderately and/or highly selective

[5] For details about the sample restriction, see Appendix Table A1.

college (versus being admitted to non-selective colleges only), and the probability of being admitted to at least one highly selective college (versus being admitted to moderately selective or open-access institutions only). Table 1 provides descriptive statistics on key outcome measures for the full sample and breaks them down according to students' DE status. On a descriptive basis, it seems that DE students on average had consistently better college application and admission outcomes than their non-DE peers.

**Table 1**
**Summary Statistics of 2007 and 2012 Ninth-Grade Cohorts**

| Characteristics and Outcomes | All Students | | Non-DE Students | DE Students |
|---|---|---|---|---|
| *Student characteristics* | | | | |
| Female | 0.50 | (0.50) | 0.48 | 0.61 |
| White | 0.51 | (0.50) | 0.48 | 0.62 |
| Black | 0.19 | (0.40) | 0.21 | 0.13 |
| Hispanic | 0.24 | (0.43) | 0.26 | 0.19 |
| Other races | 0.05 | (0.22) | 0.05 | 0.06 |
| 2007 cohort | 0.52 | (0.50) | 0.53 | 0.44 |
| 2012 cohort | 0.48 | (0.50) | 0.47 | 0.56 |
| Free or reduced-price lunch (FRPL) students | 0.45 | (0.50) | 0.49 | 0.31 |
| Limited English proficiency (LEP) students | 0.18 | (0.38) | 0.19 | 0.13 |
| Grade 9 GPA | 2.79 | (0.72) | 2.66 | 3.35 |
| Grade 9 credits earned | 7.38 | (2.46) | 7.36 | 7.48 |
| Graduated from high school | 0.94 | (0.24) | 0.92 | 0.99 |
| *Student characteristics in high school* | | | | |
| Female | 0.48 | (0.04) | 0.48 | 0.49 |
| Black | 0.21 | (0.17) | 0.21 | 0.19 |
| Hispanic | 0.25 | (0.23) | 0.26 | 0.23 |
| Other races | 0.05 | (0.02) | 0.05 | 0.05 |
| LEP | 0.19 | (0.19) | 0.19 | 0.17 |
| FRPL | 0.55 | (0.16) | 0.56 | 0.52 |
| *Outcomes* | | | | |
| Number of four-year schools applied to | 0.53 | (1.05) | 0.41 | 1.07 |
| Number of four-year schools admitted to | 0.29 | (0.45) | 0.23 | 0.56 |
| Likelihood of applying to any four-year schools | 0.27 | (0.33) | 0.21 | 0.53 |
| Likelihood of applying to at least a moderately selective four-year school | 0.11 | (0.32) | 0.08 | 0.26 |
| Likelihood of applying to at least a highly selective four-year school | 0.35 | (0.76) | 0.26 | 0.76 |
| Likelihood of being admitted to any four-year schools | 0.20 | (0.40) | 0.15 | 0.43 |
| Likelihood of being admitted to at least a moderately selective four-year school | 0.20 | (0.29) | 0.15 | 0.44 |
| Likelihood of being admitted to at least a highly selective four-year school | 0.08 | (0.27) | 0.05 | 0.18 |
| Observations | 115,413 | | 94,218 | 21,195 |

## 4. Methodology

Because most of the districts use a cutoff GPA of 3.0 to determine a student's eligibility for DE programs, we use a regression discontinuity (RD) design to compare college application and admission outcomes for students with a cumulative 10th-grade GPA just above 3.0—the required GPA cutoff for DE—to outcomes of students just below this cutoff. These students sharply differ in their likelihood of participating in DE but are otherwise very similar. Accordingly, any discontinuous jump in student outcomes around the cutoff can be interpreted as the causal impact of DE participation for students who are on the margin of meeting the participation criteria.

The traditional sharp RD method assumes full compliance with the program assignment based on the cutoff. In the context of the current study, however, many students who were eligible for DE chose not to enroll in these programs: Only 37.7% of students above the 3.0 cutoff score (i.e., DE-eligible students) participated in DE. Similarly, 5.3% of students below the GPA cutoff score ended up participating in DE anyway. As shown in Figure 1, the average probability of DE participation is less than 1 above the cutoff and more than 0 below the cutoff due to noncompliance. To address potential bias associated with noncompliance, we use a fuzzy regression discontinuity (FRD) design, where the GPA requirement is used as an instrumental variable for actual DE credits attempted, and employ a two-stage least squares (2SLS) strategy to provide a consistent estimate of the effects of DE for compilers, students whose likelihood to dual enroll is affected by cutoff crossing. We estimate the following specification in the first stage:

$$DE_i = \alpha_1 + \alpha_2 + \alpha_3 Below_i + \alpha_4 (Below * GPA\ Distance_i\ ) + \alpha_5 X_i + \epsilon_i \qquad (1)$$

where $DE_i$ indicates the number of DE credits attempted in grades 11 and 12;[6] $GPA\ Distance_i$ is the distance between the 10th-grade GPA for student *i* and the 3.0 GPA

[6] Instead of DE credits attempted in 11th and 12th grade, we test for an alternative treatment status, in which we use a dummy variable equal to 1 if a student ever enrolled in DE in 11th and 12th grade. Under this alternative treatment, the F-statistic for the excluded instrument in the first stage is under 10, which indicates that the instrument is too weak for this treatment. In addition, students with GPA below the cutoff can also participate in DE courses, but the DE courses these students enrolled in tended to be of a lower credit value and did not count toward the General Education requirement in college. For these two reasons, we have chosen DE credits attempted as the treatment instead of DE participation.

cutoff, with negative values indicating scores below the cutoff; and $Below_i$ is a binary variable of whether or not the student was eligible to participate in DE. The interaction term between DE eligibility and the running variable allows different slopes above and below the 3.0 cutoff score. Finally, $X_i$ is a vector of individual-level covariates including gender, race dummies, age, cohort year, limited English proficiency (LEP), and free or reduced-price lunch (FRPL) status in 10th grade.

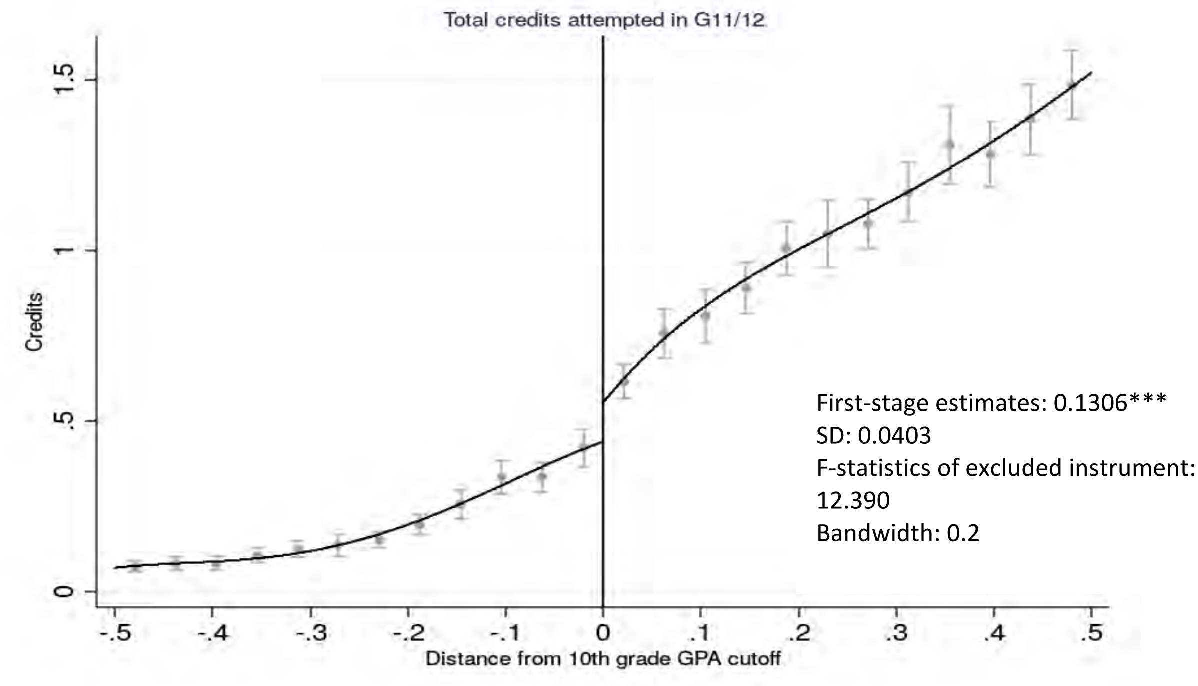
In our second stage, we estimate the local average treatment effects (LATE) within a bandwidth of 0.2 to the GPA cutoff with uniform kernels as follows:

$$y_i = \beta_1 + \beta_2 \widehat{DE_i} + \beta_3 GPA\ Distance_i + \beta_4 Below_i + \beta_5 (Below * GPA\ Distance_i\ ) + \beta_6 X_i + \in_i \quad (2)$$

Let $Y_i$ be an outcome of interest for student $i$; $\widehat{DE_i}$ is estimated in the first stage, where we predict DE credits attempted as a function of the GPA requirement. $\varphi_1$ captures the impacts of participating in DE. In all regressions, we control for high school characteristics, such as percent of 10th-grade students who are female, Black, Hispanic, or other races, or have LEP status, FRPL status, or American citizenship. We also provide reduced-form estimates that identify the effect of DE eligibility on all of the outcome measures to aid interpretation (i.e., the intent-to-treat [ITT] effect).

A causal interpretation of the 2SLS estimate in a FRD requires a strong first stage. Figure 1 presents the plot establishing the differences in the cumulative number of DE credits attempted in grades 11 and 12 for students scoring above and below the 10th-grade GPA cutoff. It displays a noticeable jump in the number of DE credits attempted at the cutoff. In addition, we also conduct several tests to ascertain the validity of the RD design (see Appendix Figures A1–A3 and Table A2) and show results for alternative bandwidths (see Appendix Table A3). Detailed explanations of these validity checks and their results are presented in the Appendix.

**Figure 1**
**Dual Enrollment Credits Attempted in 11th & 12th Grade by 10th-Grade Cumulative GPA**



# 5. Main Results

## 5.1 Effect on College Application Choice and Success

We begin by examining the graphical evidence and determining whether there are visible discontinuities in the outcome measures at the cutoff (Figures 2A and 2B). Descriptive findings show that students seemed to benefit from DE. Students scoring right above the 3.0 GPA cutoff were also more likely to apply to moderately selective and highly selective colleges. And they got admitted to a higher number of colleges, regardless of their selectivity.

The statistical estimates in Table 2 further confirm the patterns shown in Figures 2A and 2B. For each outcome, the first and second rows report ITT and FRD results, respectively. To test for the sensitivity of our estimates to different bandwidths, we also include the results using narrower (0.15 points) and wider (0.25 points) bandwidths in the Appendix.

The ITT results indicate that while eligibility for DE did not have any impact on the number of four-year colleges a student applied to, it did increase the chance of applying to any moderately or highly selective four-year college in the state (Panel A). Furthermore, eligibility for DE increased the total number of four-year colleges a student got admitted to and the likelihood of gaining admission to a highly selective four-year college (Panel B).

The FRD estimates are generally consistent with the ITT results. Focusing on the second row, we see that attempting an additional DE credit increased the number of four-year colleges a student applied to by 0.27 and the chances of applying to an at least moderately and at least highly selective four-year college by 9.3 and 10.2 percentage points, respectively. These positive impacts seem to be driven primarily by the increased probability of applying to a highly selective four-year college. Overall, the findings suggest that DE potentially increased students' confidence and aspirations to apply to a higher number of colleges and to more selective colleges.

Next, we look at whether applying to highly selective colleges resulted in a better chance of getting admitted to any four-year colleges and to highly selective colleges. The ITT and FRD are again consistent with each other. The FRD results in Panel B show that attempting an additional DE credit in grades 11 or 12 had a positive impact on the number of four-year colleges a student got admitted to (0.17) and on the likelihood of being admitted to highly selective four-year colleges (7.7 percentage points per DE credit).

**Figure 2A**
**Number of Four-Year Colleges Applied to and the Highest Selectivity of Four-Year Colleges Applied to by 10th-Grade GPA**

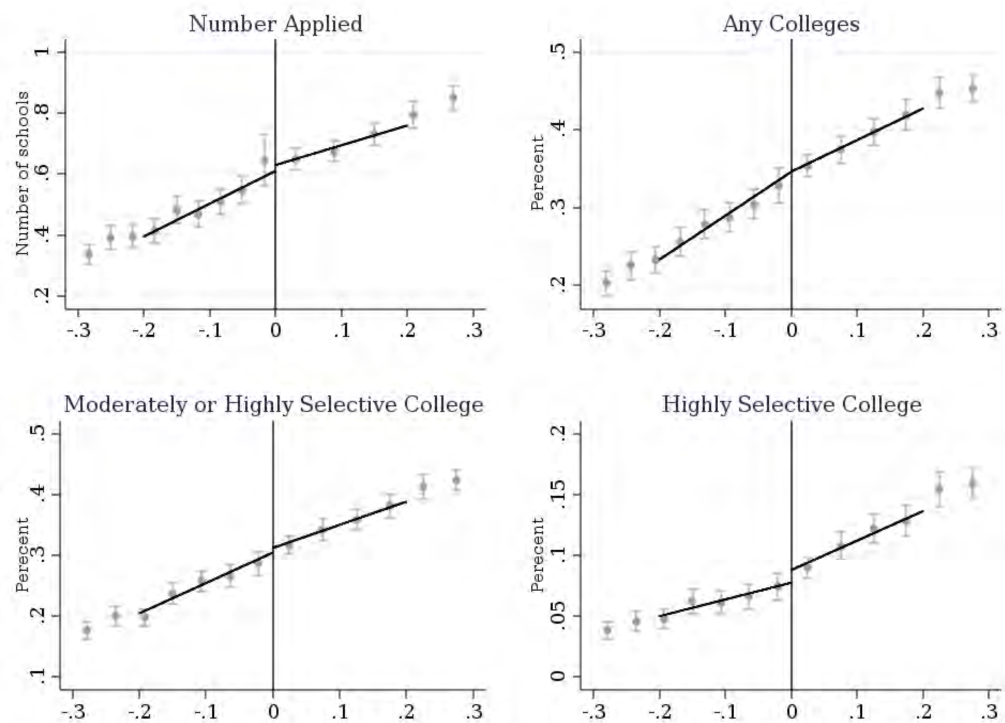


**Figure 2B**
**Number of Four-Year Colleges Admitted to and Highest Selectivity of Four-Year Colleges Admitted to by 10th-Grade GPA**

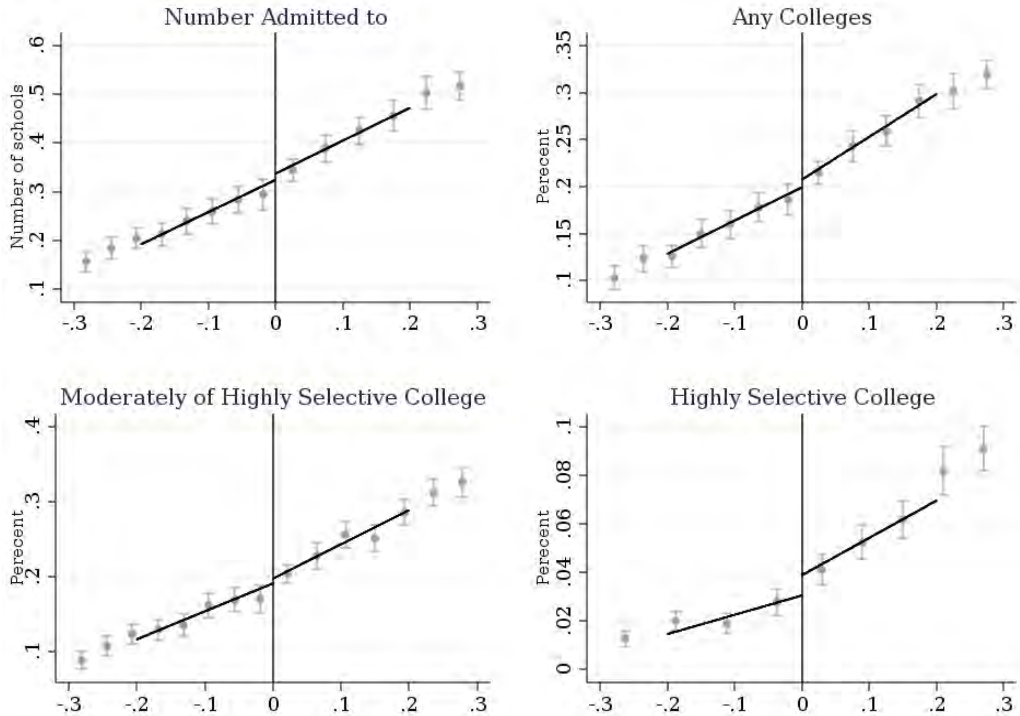


**Table 2**
**Impacts of DE on Application and Admission Outcomes to Four-Year Colleges (bandwidth = 0.2)**

| | Number of schools applied to | Likelihood of applying to any four-year schools | Likelihood of applying to moderately or highly selective four-year schools | Likelihood of applying to highly selective four-year schools |
|---|---|---|---|---|
| *Panel A. Application Outcomes* | | | | |
| Intent-to-treat estimates | 0.0307 | 0.0062 | 0.0105** | 0.0129*** |
| | (0.020) | (0.006) | (0.004) | (0.004) |
| Fuzzy regression discontinuity estimates | 0.2695* | 0.0638 | 0.0932** | 0.1021*** |
| | (0.1461) | (0.0458) | (0.0377) | (0.0334) |
| Mean | 0.5988 | 0.3377 | 0.3021 | 0.0879 |
| *N* | 23,303 | 23,303 | 23,303 | 23,303 |
| | **Number of schools admitted to** | **Likelihood of being to any four-year schools** | **Likelihood of being admitted to moderately or highly selective four-year schools** | **Likelihood of being admitted to highly selective four-year schools** |
| *Panel B. Admission Outcomes* | | | | |
| Intent-to-treat estimates | 0.0206* | 0.0134* | 0.009 | 0.0102*** |
| | (0.011) | (0.007) | (0.007) | (0.003) |
| Fuzzy regression discontinuity estimates | 0.1703* | 0.1091 | 0.0765 | 0.0770** |
| | (0.0909) | (0.0665) | (0.0584) | (0.0329) |
| Mean | 0.3306 | 0.2080 | 0.1982 | 0.0385 |
| *N* | 23,303 | 23,303 | 23,303 | 23,303 |

*Note*. Each cell represents a separate regression within a 0.2 GPA bandwidth. Each regression controls for individual characteristics (gender, race dummies, age, LEP, and FRPL status in 10th grade) as well as high school characteristics (percent of 10th-grade students who are female, Black, Hispanic, or other races, have LEP status, FRPL status, or American citizenship). Standard errors are in parentheses.

***$p < 0.001$. **$p < 0.01$. *$p < 0.05$.

### 5.2 Heterogeneous Analysis

Our results thus far establish that DE had an overall positive impact on application and admission. Given the equity concern over the racial gap for college application and enrollment (Hoxby & Avery, 2013), we further examine whether these effects were different for racially minoritized students relative to White students. Panel A of Table 3 presents the FRD estimates of the interaction term between the treatment variable (DE credits attempted) and a dichotomous variable of being a Black versus White student. This interaction term shows whether there were any significant differences in the DE impact among students from these two racial groups.

Our results indicate that DE had differential impacts on Black and White students. DE was more likely to induce Black students, but not White students, to apply to any four-year colleges and submit a higher number of applications overall. Compared to White students, each DE credit Black students attempted increased the number of colleges they applied to by 0.4 colleges and the chance of applying to any four-year college by 15.6 percentage points. While the coefficients for applying to at least a highly selective university are positive for both Black and White DE students, the standard errors are large, and these coefficients are barely statistically insignificant. Similarly, Panel B shows that DE increased the number of colleges a student was admitted to (by 0.1 colleges) and the overall admission rate to any four-year college (by 6.7 percentage points) for Black students only, while DE had a similar effect on the rate of admission to the most selective schools for both groups of students (by 7.4 percentage points).

Panels C and D present the heterogeneous DE effects for Hispanic students relative to White students. DE affected neither the overall number of applications Hispanic and White students submitted nor the overall application rate to any four-year college. However, DE did substantially increase Hispanic students' likelihood of applying to at least a moderately selective college (by 4.1 percentage points). It had a similar effect on both groups of students when it comes to applying (by 7.4 percentage points) and being admitted to (by 6.9 percentage points) at least a highly selective college.

To conclude, the effect of DE on applying to less selective and moderately selective four-year colleges was driven by Black students, while the effects of applying to the most selective colleges were driven by White and Hispanic students. Similarly, the positive effect of DE on getting accepted by moderately selective colleges was concentrated on Black students, while the positive effect of DE on getting accepted by the highly selective colleges was concentrated on White and Hispanic students.

**Table 3**
**Heterogeneous Impacts of DE on Application and Admission Outcomes to Four-Year Colleges (bandwidth = 0.2)**

| | Number of schools applied to | Likelihood of applying to any four-year schools | Likelihood of applying to moderately or highly selective four-year schools | Likelihood of applying to highly selective four-year schools |
|---|---|---|---|---|
| *Panel A. Application Outcomes* (*N: 16.366)* | | | | |
| FRD estimates | 0.183 | 0.007 | 0.051 | 0.065 |
| | (0.1301) | (0.0411) | (0.0321) | (0.0437) |
| FRD estimates * Black | 0.4068*** | 0.1557*** | 0.0693** | 0.023 |
| (Base group: White) | (0.0626) | (0.0242) | (0.0286) | (0.0182) |
| | Number of schools admitted to | Likelihood of being admitted to any four-year schools | Likelihood of being admitted to moderately or highly selective four-year schools | Likelihood of being admitted to highly selective four-year schools |
| *Panel B. Admission Outcomes* (*N: 16.366)* | | | | |
| FRD estimates | 0.094 | 0.015 | 0.057 | 0.0736** |
| | (0.0975) | (0.0457) | (0.0454) | (0.0372) |
| FRD estimates* Black | 0.0970* | 0.0668*** | -0.041 | 0.005 |
| (Base group: White) | (0.0508) | (0.0250) | (0.0331) | (0.0178) |
| | Number of schools applied to | Likelihood of applying to any four-year schools | Likelihood of applying to moderately or highly selective four-year schools | Likelihood of applying to highly selective four-year schools |
| *Panel C. Application Outcomes* (*N: 18,171)* | | | | |
| FRD estimates | -0.009 | -0.053 | -0.006 | 0.0743*** |
| | (0.1787) | (0.0651) | (0.0554) | (0.0275) |
| FRD estimates* Hispanic | 0.075 | 0.027 | 0.0411* | 0.011 |
| (Base group: White) | (0.0637) | (0.0316) | (0.0230) | (0.0160) |
| | Number of schools admitted to | Likelihood of being admitted to any four-year schools | Likelihood of being admitted to moderately or highly selective four-year schools | Likelihood of being admitted to highly selective four-year schools |
| *Panel D. Admission Outcomes* (*N: 18,171)* | | | | |
| FRD estimates | 0.100 | (0.0461) | 0.037 | 0.0691*** |
| | (0.1188) | (0.0588) | (0.0379) | (0.0214) |
| FRD estimates* Hispanic | 0.030 | 0.019 | 0.009 | -0.011 |
| (Base group: White) | (0.0408) | (0.0206) | (0.0160) | (0.0101) |

*Note*. Panels A and B include White and Black students only, while Panels C and D contain White and Hispanic students only. Each cell represents a separate regression within a 0.2 GPA bandwidth. Each regression controls for individual characteristics (gender, race dummies, age, LEP, and FRPL status in 10th grade) as well as high school characteristics (percent of 10th-grade students who are female, Black, Hispanic, or other races, have LEP status, FRPL status, or American citizenship). Standard errors are in parentheses.

***$p < 0.001$. **$p < 0.01$. *$p < 0.05$.

## 6. Discussion and Conclusion

Using administrative data that match high school DE program enrollment with college application and admission records in an anonymous state, this study indicates that while DE participation was not associated with a higher probability of applying to college overall, it led to meaningful increases in the probability of applying to more colleges and more selective colleges, as well as a higher chance that a student would get admitted to more colleges and more selective institutions. Moreover, the benefits of DE participation for college application and admission are particularly pronounced among Black students, which suggests that DE has the potential to address the persistent racial gaps in applying to selective institutions conditional on academic performance (e.g., Hoxby & Turner, 2013).

Our study is most closely related to that of Hemelt et al. (2020), which found experimental evidence that enrollment in DE math courses induces some students to enroll in four-year colleges instead of two-year colleges. Their findings provide critical evidence of the potential of DE programs to improve access to four-year colleges. Yet, it is unclear whether such effects are driven by student choice— students being more likely to apply to four-year colleges as a result of taking DE math courses—or by institutional choice— four-year colleges being more likely to admit students with DE experience with everything else being equal. Understanding the impacts of DE participation on student choice is particularly important as existing studies show that student application decisions, rather than college admission decisions, drive most deviations from academic assortative matching (Dillon & Smith, 2017). Many high-achieving students from low-income families do not apply to any selective college, even though these colleges better match their academic performance and typically cost less for low-income students to attend (e.g., Hoxby & Turner, 2013).

Our findings provide direct evidence that DE programs have the potential to alter student college choice by encouraging students to apply to more selective institutions and that such effects are pronounced among Black students. Our results suggest that DE programs, in addition to increasing college access, can be further leveraged to help students optimize their college choice. Our study is also related to the broader college choice literature that examines how students from different backgrounds sort into colleges of varying qualities, and it identifies potential ways to help students make more informed decisions (e.g., Hoxby & Turner, 2013).

Our findings should be interpreted in light of several caveats. First, as in all studies that rely on an RD design, our findings are based on local comparisons of students around the eligibility threshold for DE enrollment. It is thus an open question whether the benefits identified for students around the GPA cutoff (i.e., 3.0) would generalize to either higher performing or lower performing students that are further away from the cutoff score. In addition, our data include student applications to only in-state colleges. While students' in-state college choice portfolios should reflect their overall choice preference, future research focusing on students' complete college choice portfolios may wish to validate findings from the current study.

Despite these caveats, the evidence of positive impact on college application behaviors and admission outcomes identified in this study suggests that DE programs may present benefits to students beyond simply expanding college access. Future research should focus on what mechanisms are driving these results. For example, do DE students apply to more selective schools because they feel more confident in their chances of getting admitted to selective colleges or because they feel more ready for a selective college after taking rigorous college courses through DE? In view of the impacts of DE participation on admission success, we also recommend directly exploring the role DE courses play in the decision-making made by college admission offices. A closer examination of the mechanisms driving the benefits identified in this study will provide valuable insights on how best to help students optimize their preparation for college and college choice, especially for racially minoritized students.

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# Appendix

## Sample Restriction

The details of our sample restriction are highlighted in Table A1. Our initial dataset included two cohorts of around 497,800 ninth-graders from 1,250 high schools. We excluded any nontraditional high schools, such as adult learning only, correctional, fully virtual, and middle schools, which removed 540 high schools and yielded a dataset consisting of 710 high schools. We also excluded 45 high schools (14,728 students) where there is no DE. We further excluded 44 high schools (161,893 students) in which $10^{th}$-grade cumulative GPA does not seem to be used consistently as an eligibility criterion for DE participation. To do so, we regressed DE participation on $10^{th}$-grade cumulative GPA by school. Only high schools with an F-statistic above 10 are included in the analytic sample.

Next, we excluded 10,473 students without any $9^{th}$- and $10^{th}$-grade high school transcripts as they may have dual enrolled in other non-public in-state high schools, and we are not able to control for those academic records. Finally, since 90% of DE students dual enrolled for the first time in $11^{th}$ or $12^{th}$ grade, we restricted the sample to students who have enrollment records from $9^{th}$ through $11^{th}$ grade and had no DE participation before $11^{th}$ grade. These restrictions give us a total of 115,413 students in our analytical sample.

## Validity Tests

A causal interpretation of the 2SLS estimate in an FRD requires a strong first stage, absence of manipulation or sorting around the passing cutoff, monotonicity, and excludability. The assignment rule determining eligibility at the cutoff must be followed with a high degree of fidelity to have a strong first stage. Figure 1 presents the plot establishing the difference in the cumulative number of DE credits attempted in grades 11 and 12 for students scoring above and below the $10^{th}$-grade GPA cutoff for our analytic sample. This figure reveals a significant jump in the number of DE credits attempted at the cutoff—while students above the cutoff attempted 0.60 DE credits, students below the cutoff attempted an average of 0.44 credits. This jump, once subject to formal statistical testing, reflects a significant discontinuity at the cutoff.

A significant discontinuity at the cutoff presents a potential threat to validity if students can systematically manipulate their GPAs—whether they scored above or below the cutoff for DE eligibility. We check for covariate balance and smoothness of the density of the running variable at the cutoff. Table A2 and Figure A1 present balance checks for our analytic sample. Table A2 presents differences in means between students who were marginally eligible to attempt DE credits and those who were not. Reassuringly, coefficients are all small in magnitude and precisely estimated, indicating that students at either side of the cutoff in the main bandwidth are very similar to each other. Figure A2 presents a density plot of students around the $10^{th}$-grade GPA cutoff by cohort to assess whether there is a disproportionate number of cases stacked on either side of the cutoff, which would indicate potential manipulation. Figure A2 shows what appears to be some disproportionate stacking at the 3.0 GPA cutoff, but that stacking reappears at every 0.5 GPA point, indicating more of a grading preference at a 0.5-point interval than manipulation of grades. Once subject to formal testing, we do not find evidence of significant manipulation at the cutoff. We utilize the nonparametric local-polynomial density estimator approach developed by Cattaneo et al. (2020) to test for manipulation after conditioning the $10^{th}$-grade GPA by observable characteristics. The results are shown in Figure A3 and reveal a failure to reject the null hypothesis of no change in the density of students at the cutoff.

Finally, we test for the sensitivity of excluding covariates from our specification. The first and second rows of Table A3 present results excluding covariates (controlling only for $10^{th}$-grade cumulative GPA, a dummy variable for being above the cutoff, and an interaction of the two terms) and results including covariates, respectively. The two sets of results are generally consistent, while the estimates including the covariates are larger and estimated more precisely.

**Figure A1**
**RD Validity Check: 10th-Grade Cumulative GPA Distribution by Student Demographics**

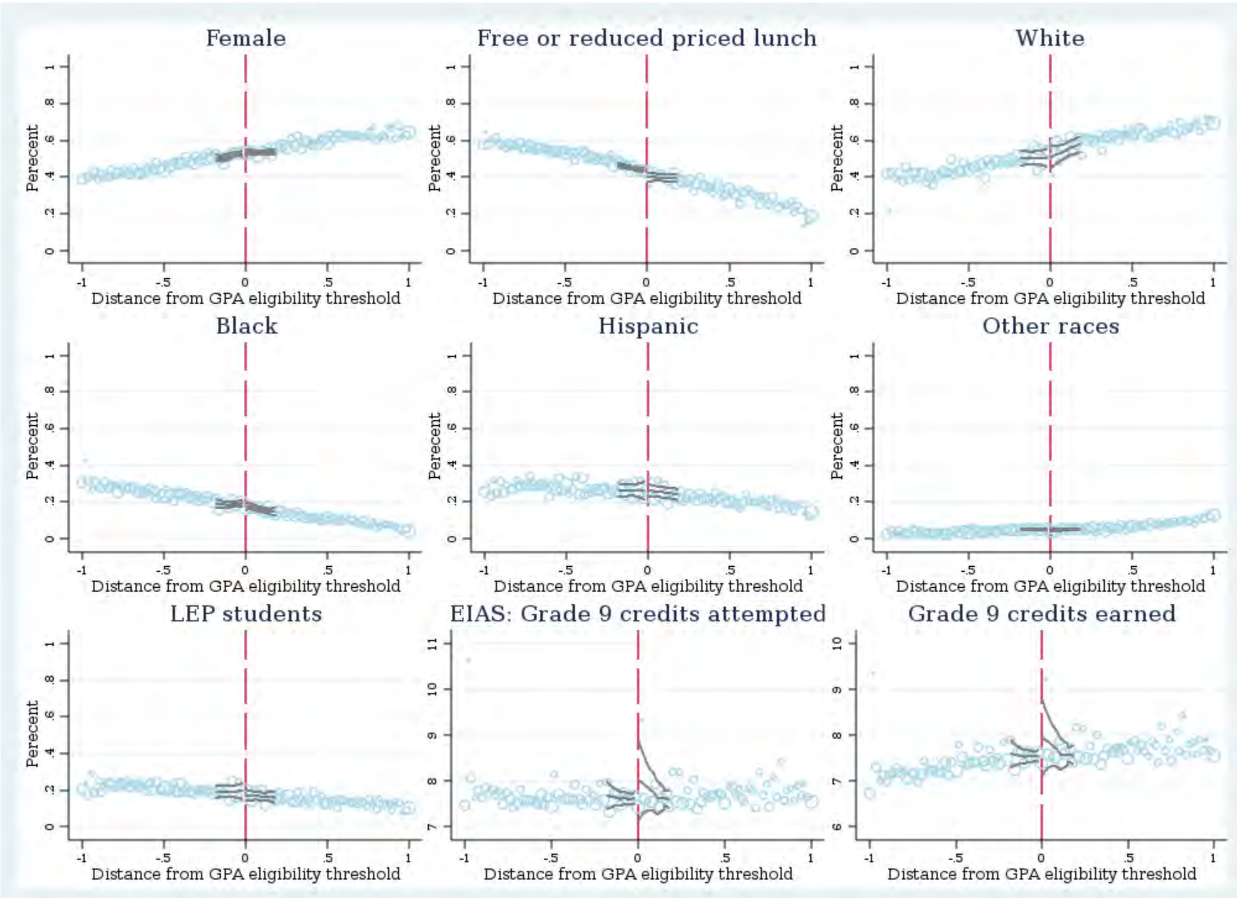


**Figure A2**
**RD Validity Check: Density of Observation Around Cutoff**

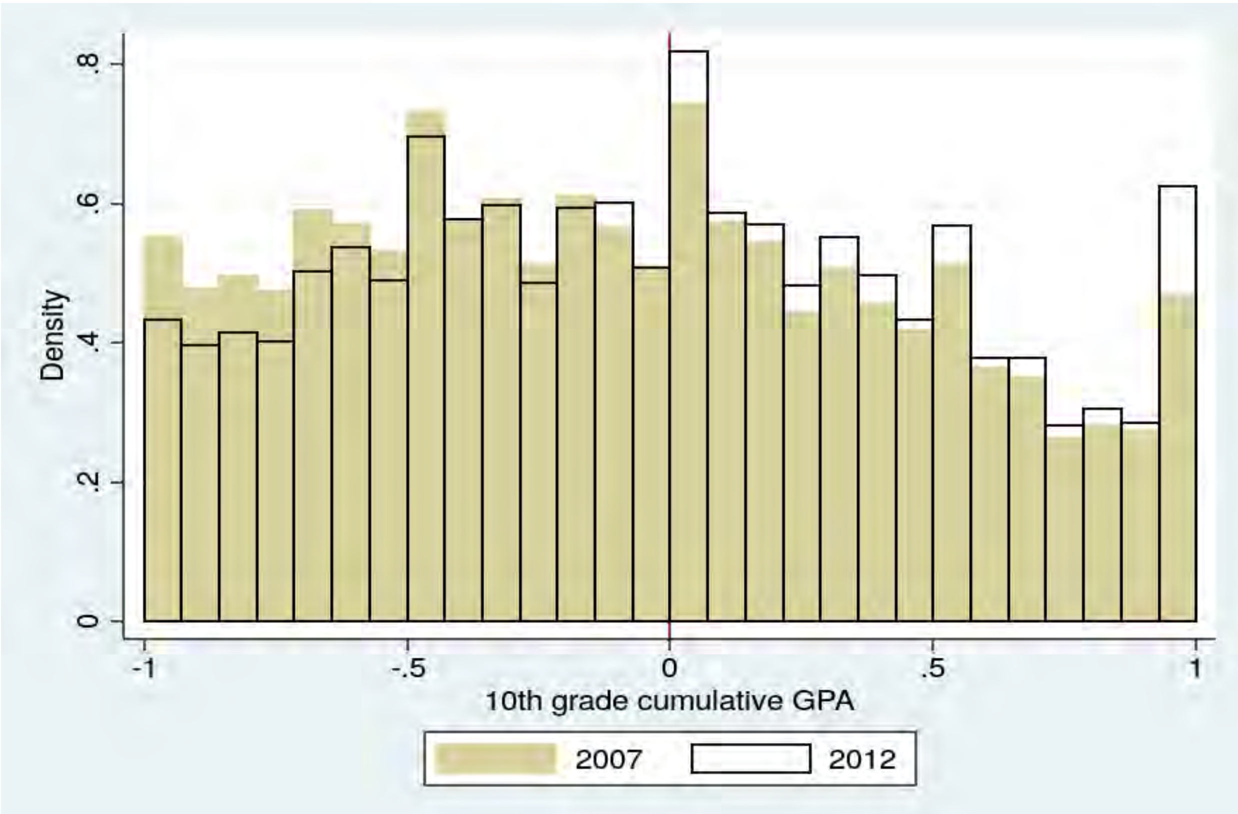
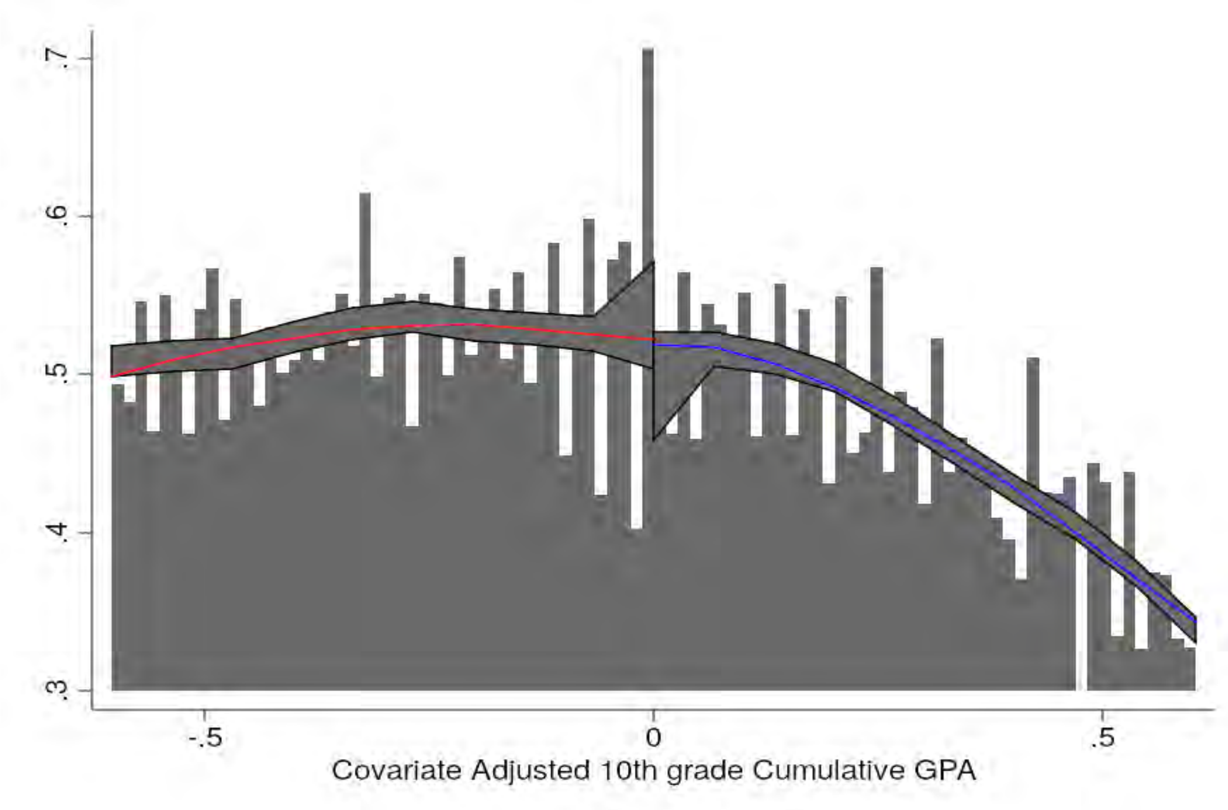


**Figure A3**
**Density Test (Cattaneo et al., 2020)**




*Note*. RD Manipulation test result (T = 1.3153, P > |T| = 0.1884)

**Table A1**
**Sample Restriction and Size**

| Restriction | Number of Students |
|---|---|
| Initial dataset | 497,771 |
| Exclude non-traditional high school | 307,962 |
| Exclude high schools with no DE students | 293,234 |
| Exclude schools with high noncompliant rate for DE GPA criterion | 131,341 |
| Exclude students with no $9^{th}$- and $10^{th}$-grade records | 120,868 |
| Exclude students with DE before $11^{th}$ grade | 115,413 |
| Within 0.2 bandwidth from the 3.0 GPA cutoff | 23,303 |

**Table A2**
**Balance Check of Student Demographics at Cutoff**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | Female | White | Black | Hispanic | FRPL students | LEP students | Grade 9 GPA | Grade 9 credits earned |
| *Panel A. Excluding Other Covariates* | | | | | | | | |
| DE credits | -0.1659 | 0.1244 | -0.0236 | -0.0990 | -0.0092 | -0.2244 | -0.0411 | 0.8001 |
| | (0.1252) | (0.2073) | (0.1018) | (0.2133) | (0.0844) | (0.1706) | (0.0399) | (1.5465) |
| Observations | 23,303 | 23,303 | 23,303 | 23,303 | 23,303 | 23,303 | 23,303 | 23,303 |
| R-squared | -0.280 | -0.089 | 0.000 | -0.091 | 0.006 | -0.695 | 0.132 | -0.257 |
| *Panel B. Including Other Covariates* | | | | | | | | |
| DE credits | 0.0052 | 0.0005 | 0.0070 | -0.0008 | -0.0134 | -0.1886** | -0.0419 | 0.7515 |
| | (0.0982) | (0.0049) | (0.0151) | (0.0056) | (0.0726) | (0.0886) | (0.0742) | (1.2853) |
| Observations | 23,303 | 23,303 | 23,303 | 23,303 | 23,303 | 23,303 | 23,303 | 23,303 |
| R-squared | 0.017 | 0.997 | 0.994 | 0.996 | 0.255 | -0.250 | 0.183 | -0.150 |

***$p < 0.001$. **$p < 0.01$. *$p < 0.05$.

**Table A3**

**Impacts of DE on Application and Admittance Outcomes with Alternative Bandwidths**

| Bandwidth = 0.15 | Number of schools applied to | Likelihood of applying to any four-year schools | Likelihood of applying to moderately or highly selective four-year schools | Likelihood of applying to highly selective four-year schools |
|---|---|---|---|---|
| *Panel A. Application Outcome* | | | | |
| FRD estimates | 0.1782 | 0.0528 | 0.0989*** | 0.0537* |
| N = 17,980 | (0.1238) | (0.0437) | (0.0331) | (0.0325) |
| | Number of schools admitted to | Likelihood of being admitted to any four-year schools | Likelihood of being admitted to moderately or highly selective four-year schools | Likelihood of being admitted to highly selective four-year schools |
| *Panel B. Admittance Outcome* | | | | |
| FRD estimates | 0.1617 | 0.1443** | 0.1065 | 0.0628 |
| | (0.1137) | (0.0657) | (0.0822) | (0.0494) |

| Bandwidth = 0.25 | Number of schools applied to | Likelihood of applying to any four-year schools | Likelihood of applying to moderately or highly selective four-year schools | Likelihood of applying to highly selective four-year schools |
|---|---|---|---|---|
| *Panel C. Application Outcome* | | | | |
| FRD estimates | 0.1770* | 0.0475 | 0.0677** | 0.0683*** |
| N = 17,980 | (0.0937) | (0.0307) | (0.0305) | (0.0247) |
| | Number of schools admitted to | Likelihood of being admitted to any four-year schools | Likelihood of being admitted to moderately or highly selective four-year schools | Likelihood of being admitted to highly selective four-year schools |
| *Panel D. Admittance Outcome* | | | | |
| FRD estimates | 0.1506** | 0.1004** | 0.0748 | 0.0477 |
| | (0.0686) | (0.0429) | (0.0503) | (0.0322) |

***$p < 0.001$. **$p < 0.01$. *$p < 0.05$.

**Table A4**

**Sensitivity Test of Covariates Exclusion to the Impacts of DE (bandwidth = 0.2)**

| | Number of schools applied to | Likelihood of applying to any four-year schools | Likelihood of applying to moderately or highly selective four-year schools | Likelihood of applying to highly selective four-year schools |
|---|---|---|---|---|
| *Panel A. Application Outcome* | | | | |
| Without covariates | 0.1107 | -0.0044 | 0.0504 | 0.0748* |
| | (0.2263) | (0.0830) | (0.0912) | (0.0438) |
| With Covariates | 0.2695* | 0.0638 | 0.0932** | 0.1021*** |
| | (0.1461) | (0.0458) | (0.0377) | (0.0334) |
| Mean | 0.5988 | 0.3377 | 0.3021 | 0.0879 |
| N | 23,303 | 23,303 | 23,303 | 23,303 |

| | Number of schools admitted to | Likelihood of being admitted to any four-year schools | Likelihood of being admitted to moderately or highly selective four-year schools | Likelihood of being admitted to highly selective four-year schools |
|---|---|---|---|---|
| *Panel B. Admittance Outcome* | | | | |
| Without covariates | 0.1056 | 0.0743 | 0.0541 | 0.0666** |
| | (0.1388) | (0.0854) | (0.0832) | (0.0296) |
| With Covariates | 0.1703* | 0.1091 | 0.0765 | 0.0770** |
| | (0.0909) | (0.0665) | (0.0584) | (0.0329) |
| Mean | 0.3306 | 0.2080 | 0.1982 | 0.0385 |
| N | 23,303 | 23,303 | 23,303 | 23,303 |

*Note*. Each cell represents a separate regression within a 0.2 GPA band width. Each regression controls individual characteristics (gender, race dummies, age, LEP, and FRPL status in 10th grade) as well as high school characteristics (percent of 10$^{th}$-grade students who are female, Black, Hispanic, or other races; who have LEP status, FRPL status, and American citizenship; and who were born in a certain year). Standard errors are in parentheses.

***$p < 0.001$. **$p < 0.01$. *$p < 0.05$.