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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 on data from two cohorts of ninth-grade students in one anonymous state, we found that taking DE credits increased the likelihood of applying to highly selective in-state four-year institutions. Attempting DE credits also increased the probability of gaining admission to a highly selective in-state four-year college. Heterogeneous analysis further indicates that the gains were extended across Black, Latinx, and white student populations.

Keywords: Dual enrollment, college application, college admission, regression discontinuity

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Introduction

Improving college access and facilitating better student-college matches remain critical concerns for researchers and policy makers. This focus stems in part from the growing evidence of undermatching -- a phenomenon where many well-qualified students, especially those from historically underserved groups, do not enroll in selective colleges aligned with their academic capabilities (e.g., Baker et al., 2018; Dillon & Smith, 2017; Hill et al., 2005; Hoxby & Turner, 2013). At selective public colleges, white students are overrepresented, constituting 64% of the first-year students despite making up only 54% of the 18 to 24- year-old population. In contrast, Black and Latinx students are underrepresented, comprising just 7% and 12% of first-year students' enrollment respectively at selective public colleges (Carnevale et al., 2018).

While multiple factors might contribute to these racial and ethnic gaps in college enrollment decisions, one driving factor 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. 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. Since students can only enroll in colleges they apply to, the suboptimal choices in college application made by students from underrepresented groups are concerning from an equity standpoint. This is particularly troubling given the growing body of evidence highlighting the advantages of attending well-resourced, selective institutions, which positively impact college completion rates and subsequent labor market outcomes (Zimmerman, 2014; Black et al., 2023; Cohodes & Goodman, 2014; Hoekstra, 2009). In addition, growing evidence suggests that students from underrepresented groups, particularly black students, seem to benefit more from attending selective colleges than their white peers (Black et al., 2023; Dale & Krueger, 2011; Hoekstra, 2009).

College acceleration programs, such as dual enrollment (DE) and advance placement (AP) programs, are one way to boost college access and success. Both programs allow high school students to experience college-level courses and accumulate college credits while in high school. Advocates of college acceleration programs are 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).

However, AP and DE have meaningful differences in their reception and program structure. Although AP is often considered more prestigious than DE, it is more frequently offered in high schools with a higher proportion of affluent and white students when compared to schools that offered DE (Klopfenstein & Lively, 2012; Xu et al., 2021). Such gaps in AP access lead to equity concerns, and some have pointed to DE as a more equitable tool to boost college outcomes because it is more widely available in a diverse range of high schools, providing broader access to college-level coursework for underrepresented students (Karp, 2012; An & Taylor, 2019). 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 a large anonymous 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 to and got admitted to, as well as 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 taking DE credits increases the likelihood of both applying to and gaining admission to highly selective in-state four-year colleges. Heterogeneous analysis by race/ethnicity further indicates that the positive impacts on college application and admission outcomes span across a diverse student population, including Black, Latinx, and white 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 (e.g., Allen & Dadgar, 2012; An, 2013; Miller et al., 2018; Speroni, 2011b) primarily focused on postsecondary enrollment and performance outcomes. Overall, these studies found that DE participation had positive impacts on the probability of enrollment in a postsecondary institution and performance conditional on enrollment. 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 a null impact on overall rates of college enrollment, it induced students to enroll in four-year instead of two-year colleges (Hemelt et al., 2020). This finding is important because it highlights the possibility that DE participation might influence students' college application choices. We draw on this line of work and contribute to it by leveraging college application and admission outcomes data to directly examine the impacts of DE participation on students' college application choices and admission outcomes.

Theoretical Framework and Related Research

Theories on College Choice

The college choice models proposed by Hossler and Gallagher (1987) and Hossler et al. (1989) outline a comprehensive three-phase process. In the first phase, *predisposition*, students tentatively decide whether to pursue postsecondary education. This decision is influenced by factors such as students' characteristics, aspiration, academic achievement, high school quality, peers, and high school teachers or counselors. In the second phase, *search*, students narrow down college choices, typically beginning in the junior year of high school, as they gather information about the potential options. Common sources of information include college catalogs, campus visits, guidance counselors, and having enrolled in the college (such as dual enrollment). The final phase, *choice*, involves students making decisions based on the information gathered during the search phase, using their own evaluation criteria.

Within this framework, more recent studies have focused on the college application process as a matching mechanism that aligns individuals' college choices with subsequent admission and enrollment outcomes (Chade et al., 2014; Fu, 2014; Ali & Shorrer, 2021). The application process plays a crucial role in determining which students enroll in specific institutions, ultimately determining access to various types of institutions, with varying levels of selectivity. The theoretical literature framing college matching as a market equilibrium problem has identified crucial factors influencing students' application portfolio choices. These factors include prior academic performance, preferences for colleges, application costs, and information friction that introduces uncertainty for both students and colleges. On one hand, students, who have heterogeneous academic skills and preferences for colleges, make college application decisions amid uncertainties about application and tuition costs. On the other hand, colleges, observing imperfect measures of students' prior academic performance and fit, compete for better students by setting admissions standards and offering admission to selected groups of students.

Under this context, students face a complex decision: how many and which colleges to apply to. 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 in gathering and processing information and preparing application materials. They also endure psychic costs during this process, such as the anxiety while 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, in turn, also face information friction and market uncertainties as they seek to fill their freshman classes with the best students possible and can only observe imperfect measures of student academic performance and fit, such as student test scores, high school transcripts, DE participation, extracurricular activities, and essays.

Earning College Credits in High School and College Choice: The Impact of DE and AP

Under the college choice model, earning college credits while still in high school, typically accomplished either through DE or AP programs, can influence students' college application behavior and admission outcomes through multiple channels. First, successful experiences in college acceleration programs can enhance students' college aspirations and expectations, fostering academic self-efficacy for future college work and building both academic skills and confidence. This might alleviate students' anxiety and uncertainty about college application and boost confidence in securing admission to a selective college. Second, DE and AP programs enable students to accumulate college credits in high school, providing a financial benefit by bypassing introductory or general education courses in college. This can expedite time to degree and reduce the costs associated with attending colleges with higher tuition costs. Third, DE and AP signal students' college readiness and academic aspirations to selective colleges, potentially influencing admission outcomes and leading to a better academic match. Fourth, DE and AP programs can provide essential counseling support, systematically guiding underrepresented students toward college success. Turner (2020) illustrates the crucial role that high school counselors play in influencing Latinx students' college choices. This influence is framed within the empowerment framework developed by Hipolito-Delgado and Lee (Hipolito-Delgado & Lee, 2007), which emphasizes the importance of empowering students through targeted support and guidance. By implementing such frameworks, DE and AP programs can create intentional pathways that help underrepresented students navigate their academic journeys and achieve their college aspirations.

It is important to highlight the distinct features of DE and AP programs. DE allows students to enroll in actual college courses, often at local community colleges, while AP offers high school courses taught to college-level standards. Despite both being college acceleration programs, DE is more geographically dispersed, including in many rural communities (Xu et al., 2021). In contrast, AP is more likely to be offered in high schools with a higher proportion of white and affluent students (Klopfenstein & Lively, 2012). Nonetheless, some raise concerns that DE might channel individuals towards two-year colleges, given that many of the DE courses are offered at community colleges (Lichtenberger et al., 2014; Cowan & Goldhaber, 2015).

Existing literature has used quasi-experimental designs to explore the impact of earning college credits through DE and AP programs across an array of college outcomes. Overall, AP participation is associated with increases in degree attainment and earnings, on-time bachelor's degree completion, and a higher likelihood of majoring in a STEM field when taking AP credits in those fields (e.g., Evans, 2018; Long et al., 2012; Avery & Goodman , 2022; Gurantz, 2021; Jackson & Kirabo, 2014; Klopfenstian & Thomas, 2009). Similarly, DE research provides evidence that high school students taking DE courses are more likely to attend college and complete college credentials than students who do not (Allen & Dadgar, 2012; Giani et al., 2014; Henneberger et al., 2022; Ison, 2022; Lee et al., 2022; Liu et al., 2020; Miller et al., 2018; An, 2013; Speroni, 2011a). A recent What Works Clearinghouse (WWC) report (U.S. Department of Education, 2017) reinforced these findings, summarizing positive effects of DE on high school grades, high school completion, college enrollment, college credit accumulation, and college degree completion. Positive effects are also noted for low-income students and students of color in particular, though varying in the size of the estimated effects across studies (Allen & Dadgar, 2012; An, 2013; Taylor, 2015; Karp et al., 2007).

While the literature on DE and AP's impact on postsecondary success is well-established**,** there is less knowledge regarding the impact of earning college credits in high school on students' college choice. This is largely due to the lack of data linking AP/DE program participation with college application and admission records. Among the handful of studies that examined this issue, they primarily focused on AP credits. For example, using data from the National Student Clearinghouse, the College Board, and ACT, Inc., Conger et al. (2023) and Smith et al. (2017) provided empirical evidence on the impact of AP exam scores and coursetaking on students' college application choice and enrollment. Conger et al. (2023) 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. Using a regression discontinuity design (RDD), Smith et al. (2017) found that students who scored a 3-point score as opposed to a 2 on the English exam were associated with an increase of approximately 0.105 (2.5%) in the number of SAT scores sent to colleges.

Due to the distinct features of AP compared to DE, it remains unclear whether the evidence about the impact of AP coursetaking on college application choices and admission outcomes might apply to DE participation. Perhaps the most relevant DE studies are by Hemelt et al. (2020) and Lee et al. (2022). Hemelt et al. (2020) 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. Likewise, the propensity score estimates in Lee et al. (2022) also show a diversion toward enrolling in four-year colleges. These are important findings, as they highlight the possibility that DE participation might either encourage students to apply to more selective colleges or increase their chance of being admitted to a selective college, or both. Yet, the lack of application and admission data in both Hemelt et al. (2020) and Lee et al. (2022) prevents a comprehensive understanding of these mechanisms.

Our study builds on the current literature by examining the impact of DE participation on students' college application choices and admission outcomes directly. 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 RDD. Results from our study might 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.

Data and Setting

State Context in Dual Enrollment

This study was conducted within 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 official state records, the number of DE students doubled between 2010 and 2019, culminating in approximately 70,000 students during the academic year 2019-2020. Participation in DE is open to all public schools, charter schools, private schools, and home education programs, provided there is an articulation agreement with the participating postsecondary institution. The state covers tuition, registration, and laboratory fees for all DE courses. Additionally, students enrolled at public high schools are also eligible to receive any DE instructional materials free of charge.

[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.

In general, students in grades 6–12 are required to maintain a minimum cumulative GPA of 3.0 to be eligible for academic DE courses.[2] However, the cutoff score for a particular course might vary across districts and postsecondary institutions. The majority of DE students in this state take college-level courses that are intended to fulfill associate or bachelor's degree requirements.[3] Over 80% of the DE participants at the state's community colleges take freshman- and sophomore-level academic courses, while the remaining students pursue career-technical and apprenticeship coursework.[4] Notably, the two most popular DE courses are College Algebra and Freshman Composition, accounting for one-third of all DE course enrollments.[5]

DE courses offered at community colleges can be taken in different modalities, including on a state college campus, at an off-campus college extension center, in a high school, or online. When taught off-campus, DE instructors are required to hold an advanced degree in the subject they teach. It is important to note that the modality data is only available for the 2012 cohort. In our sample, approximately half of the DE students (49%) primarily participated in face-to-face delivery on campus, while another 40% engaged in face-to-face delivery off-campus. Only 9% of

[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.

[4] Our study specifically examines DE programs at community colleges and excludes analysis of DE programs at four-year colleges. This decision is driven by two key factors: First, the state introduced DE at four-year colleges post-2010, potentially limiting the statistical power to detect any effects. Second, our primary analytical sample within the bandwidth includes mostly students who did not participate in a DE course at a four-year college, mainly due to the higher GPA threshold (3.6) set by four-year institutions compared to community colleges (typically 3.0 GPA).

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

DE students primarily took courses online, although there were substantial variations across high schools.

Data and Sample Description

Our data contain five years of administrative records for two cohorts of ninth graders enrolled in any public high schools in this state. These cohorts entered ninth grade in fall 2007 and 2012, respectively, totaling roughly 500,000 students.[6] The dataset includes students' demographic information and detailed high school transcripts, covering course enrollment and performance in DE programs from ninth through twelfth grade. A notable feature of this dataset is that it also includes each student's college application portfolio, admission outcomes, and enrollment records for both two-year and four-year in-state public colleges. This unique information enables us to examine whether DE credits influence students' college choice portfolio and admission success.

However, one limitation of the data is that the application and enrollment information is restricted to public in-state institutions. Consequently, instances where a student applied to and enrolled in an in-state private institution, or an out-of-state institution are absent from our dataset. This limitation poses a substantial challenge for determining college enrollment outcomes, as students often cast a wide net when applying to colleges due to the inherent uncertainty of the application process but can only enroll in one institution. To address this, we focus on in-state application and admission outcomes, which at least partially reflect their preferences on college selectivity. By examining which in-state public colleges students apply to and are admitted to, we gain insights into the range of options they consider and the extent to

[6] The state expressed concerns about student privacy and, to protect anonymity, opted not to provide several consecutive years of data. As a compromise, they agreed to provide data for two nonconsecutive years, balancing the need for sufficient data with privacy considerations.

which they are accepted into their preferred institutions. Indeed, current studies on students' college application choices indicate that those 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). Given this context, our study specifically focuses on students' college application and admission outcomes and does not explore enrollment outcomes.

Our analytical sample contains 115,413 students, among whom 18.4% participated in DE, with 8.2% enrolling during grades 11, 15.6% during grade12, and 5.3% participating in DE in both grades.[7] 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 (61%) and white (62%) and less likely to receive free or reduced-price lunch (31%). Both DE and non-DE students in our sample came from schools with similar characteristics.

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 to which students applied. To examine whether DE encourages students to apply to more selective institutions, 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. Highly selective colleges typically admit fewer than 15 to 50% of applicants,

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

including public institutions like the University of California, Berkeley and the University of Michigan. Moderately selective universities generally accept fewer than 60% of applicants, such as Ohio State University and University of Denver. Inclusive institutions have more open admissions policies, admitting most applicants who meet basic requirements. Examples include state universities with high acceptance rates.

Similarly, we consider four specific measures for admission outcomes: (1) the total number of any in-state four-year colleges to which a student was admitted; (2) whether a student was admitted to at least one four-year college (as opposed to being admitted to none); (3) whether the student was admitted to at least one moderately and/or highly selective college (as opposed to being admitted to non-selective colleges only); and (4) whether the student was admitted to at least one highly selective college (as opposed to 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. Descriptively, it seems that DE students, on average, consistently had better college application and admission outcomes than their non-DE peers.

[Table 1]

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 RDD 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.[8] These students sharply differ in their likelihood of

[8] Eligibility for DE typically relies on the latest available GPA, meaning students would use their 11th grade GPA to meet the eligibility criteria for 12th grade DE. However, using the 11th grade cumulative GPA as a predictor can introduce endogeneity issues since it can be influenced by a student's decision to enroll in DE courses. As such, we utilize the 10th grade GPA, which precedes any DE participation in the 11th grade. Importantly, the high correlation (96.6%) between 10th and 11th grade cumulative GPAs suggest

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 RDD assumes full compliance with the program assignment based on the cutoff. However, in the context of the current study, many students 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.

To address potential bias associated with non-compliance, we use a FRD design, where the GPA requirement serves as an instrumental variable for actual DE credits attempted. We employ a two-stage least squares strategy to provide a consistent estimate of the effects of DE for compilers – students whose likelihood to DE is affected by cutoff crossing. [9]We estimate the following specification in the first stage:

$$DE_i = \alpha_1 + \alpha_2(GPA\ Distance_i) + \alpha_3 Above_i + \alpha_4(Above * GPA\ Distance_i\ ) + X_i{'}\alpha_5 +\ \epsilon_i \quad (1)$$

where DE_i indicates the number of DE credits attempted in grades 11 and 12;[10] $GPA\ Distance_i$

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that 10th grade GPA is a reliable predictor of 11th grade GPA. In our sample, 18.4% of students participated in DE, with 8.2% enrolling in the 11th grade, 15.6% in the 12th grade, and 5.3% in both grades. Notably, only 4% of the students who had a 10th grade GPA above 3.0 fell below a 3.0 GPA in the 11th grade. This high correlation and the low incidence of GPA drop-offs between 10th and 11th grades reinforce the validity of using 10th grade GPA to predict DE eligibility in the 12th grade.

[9] As a robustness check, we have also included Wald estimates in Appendix Table A2, which show results nearly identical to those from our main specification.

[10] 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. In this alternative treatment scenario, the F-statistic for the excluded instrument in the first stage falls below 10, signaling that the instrument is too weak for this treatment. Additionally, students with a GPA below the cutoff can participate in DE courses. However, it's worth noting that the DE courses these students enroll in often have a lower credit value and do not contribute towards fulfilling the General Education requirement in college. For instance, students with a GPA below 3.0 may qualify for Career Technical Education credits, which are limited to transferability to community colleges and not four-year universities. As a result, the group of DE students with a GPA below 3.0 differs significantly from students taking academic DE courses that necessitate a minimum 3.0 GPA. Considering these factors, we have opted to use DE credits attempted as the treatment variable instead of DE participation.

is the distance between the 10th-grade GPA for student *i* and the 3.0 GPA cutoff; and $Above_i$ is a binary variable indicating whether the student was eligible for 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 the second stage, we estimate the local average treatment effects within a bandwidth of 0.2 to the GPA cutoff using uniform kernels:

$$y_i = \beta_1 + \beta_2 + \beta_4 Above_i + \beta_5(Above * GPA\ Distance_i) + X_i'\beta_6 + \epsilon_i \qquad (2)$$

Let Y_i represents 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. β_2 captures the impacts of participating in DE.

In all regressions, we control for high school characteristics, such as the percent of 10th-grade students of different races; who have LEP status, FRPL status, and American citizenship; and who are born in a certain year. Additionally, we provide reduced-form estimates to identify the effect of DE eligibility on all of the outcome measures, assisting in the interpretation (i.e., the intent-to-treat [ITT] effect).

Validity Tests

The validity of our analysis relies on several key assumptions underlying a FRD. First, a strong first stage requires adherence to the assignment rule determining eligibility at the cutoff. Figure 1 illustrates the difference in the cumulative number of DE credits attempted in grades 11 and 12 for students scoring above and below the 10th-grade GPA cutoff in our analytic sample. There is a noticeable jump at the cutoff, with students above the GPA cutoff attempting an average of 0.60 DE credits and those below attempting 0.44 credits. This jump represents a significant discontinuity at the cutoff in formal statistical tests.[11]

[Figure 1]

A potential threat to the validity of the RDD is that students or teachers might systematically manipulate grades around the cutoff. For example, if students had a GPA close to 3.0 and would like to enroll in DE coursework, they might intentionally enroll in easier courses to boost their GPA above the cutoff. Similarly, teachers or administrators might manipulate grade calculations in favor of certain students (e.g., Dee et al., 2019). If students with stronger application and admission prospects clump above the cutoff, it would bias our estimates of the impact of DE on students' application and admission outcomes upward. Figure 2 explores this possibility by presenting a density plot of students around the 10^{th}-grade GPA cutoff by cohort.

While there appears to be some disproportionate stacking at the 3.0 GPA cutoff, similar patterns emerge at half-point intervals. Similar patterns of grade heaping have been noted in several previous papers (e.g., Zimmerman 2014; Barreca et al., 2016; Ost et al., 2018), which might plausibly reflect the standard grading conventions (i.e., grades are often assigned with precision to certain intervals, such as 3.0, 3.3) instead of the influence from a specific cutoff. Depending on the grading scale used, students' grades naturally cluster around specific intervals, regardless of whether there is a cutoff point affecting eligibility for certain programs. Consequently, some scholars, such as Zimmerman (2014), argue for using the ratio between

[11] Our first stage has an F-statistic of 13. While there is no universal consensus on appropriate F-statistic thresholds, an F-statistic of 10 was often considered acceptable. However, Stock and Yogo (2005) recommend an F-value greater than 16.38 for a relatively conservative level of bias/distortion, and more recently, Cattaneo and Titunik (2022) argue that the F-statistic should be above 20 when estimating a FRD to avoid weak instrument problems. Estimates from an instrumental variables approach can suffer from bias similar to naive OLS regression when the partial correlation between the instruments and the endogenous variable is small (Staiger & Stock, 1997). Given these considerations, we interpret our results with caution to be conservative due to the weak first stage F-statistic.

conditional densities to unconditional densities as a more informative visual test to detect grade manipulation in situations where a running variable might be discontinuously distributed due to external factors. The underlying idea is straightforward: if discontinuities in grade distribution arise from factors unrelated to treatment assignment, any discontinuous shifts in conditional distributions should correspond to discontinuous shifts in the overall distribution. Thus, the ratio of conditional densities to unconditional densities should exhibit continuity, even if individual densities do not.

In Figure 3, we present density ratios using Zimmerman's (2014) method for five distinct groups: female students, Black students, Latinx students, students receiving FRPL, and students with LEP. Each data point represents the ratio of observations with a specific characteristic to all observations within a 0.5 grade point bin. As expected in a valid RDD, each density ratio demonstrates continuity around the cutoff value. Nonetheless, in view of potential biases introduced by the spikes (Barreca et al., 2016), we adhere to the approach outlined by Barreca et al. (2016) and use the "donut" RDD as our primary specification, which yielded relatively conservative results.

We further check for covariate balance and smoothness of the density of the running variable at the cutoff. Table 2 and Figure 4 present balance checks for our analytic sample. Table 2 presents differences in means across various demographic characteristics between students who were marginally eligible to attempt DE credits and those who were not. Reassuringly, all coefficients, except one, are small in magnitude and imprecisely estimated, indicating that students at either side of the cutoff in the main bandwidth are very similar to each other. Figure 4 visually confirms these findings and shows that the covariates are relatively smooth right below and above the cutoff.

[Table 2 and Figures 2, 3, & 4]

To identify the causal effects of attempting DE courses, we also need to satisfy two additional assumptions, namely monotonicity and exclusion restrictions. The monotonicity assumption, which posits that there are no "defiers" (individuals who would take DE credits if they had a GPA below 3.00 but not if they had a GPA above 3.00), is crucial for the validity of our IV estimates. We argue that defiers are unlikely to exist in our context. Specifically, students' decisions to take DE credits are motivated by the perceived benefits, such as college readiness, cost savings, and advanced standing in college. It is irrational for a student who is on the cusp of eligibility to reject these benefits simply because their GPA crosses the 3.0 threshold. The exclusion restriction posits that surpassing the 3.0 GPA threshold affects outcomes solely through the pursuit of DE courses. For example, it would be problematic if the 3.0 cutoff on 10th grade cumulative GPA is also used to determine students' eligibility to other programs that could impact their college application and admission outcomes, such as eligibility for opportunity programs or financial aid. However, it is important to note that many high school opportunity programs, such as busing and FRPL, are determined by family income rather than academic performance. Moreover, most college-based financial aid programs consider GPA from later grades, such as 12th grade or college GPA, rather than 10th-grade GPA. Therefore, this requirement does not seem to pose a threat in our specific case.

Lastly, we examine the sensitivity of our results to alternative bandwidth specifications, the exclusion of covariates from our model, and the inclusion of high school fixed effects in our estimation. We will provide a detailed description of these findings in the results section, but generally these results are consistent with our main findings.

Main Results

Effect on College Application Choice and Success

We begin by examining the graphical evidence and determining whether there are discernible discontinuities in the outcome measures at the cutoff (Figures 5A and 5B). Our descriptive analysis indicates that students seemed to benefit from DE, where students scoring just above the cutoff were more likely to apply to and get admitted by highly selective colleges.

The statistical estimates in Table 3 further confirm the patterns shown in Figures 5A and 5B. For each outcome, the first and second rows report ITT and FRD results, respectively. The ITT results indicate that while the 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).

[Table 3, Figure 5A and 5B here]

The results from the FRD estimates indicate that each additional DE credit attempted in grades 11 or 12 (which roughly corresponds to one DE course) led to a significant increase of 6.9 percentage points in the likelihood of applying to at least one highly selective four-year college. The FRD results in Panel B indicate that attempting an additional DE credit in grades 11 or 12 had a positive impact on the likelihood of being admitted to highly selective four-year colleges, with an increase of 3.9 percentage points per DE credit attempted.

Heterogeneity Analysis

Our findings thus far indicate that taking more DE credits had a positive impact on both the probability of applying to and being admitted by more selective four-year colleges. Given concerns about racial disparities in college application and enrollment (Hoxby & Avery, 2013), we further examine whether these effects varied for students from racially minoritized groups relative to white students. To investigate this, we included in Table 4 estimates of the interaction between the treatment variable (DE credits attempted) and a binary variable indicating whether a student is Black or Latinx, as opposed to white. These interaction terms help us assess if there are significant differences in the impact of DE among students from these racial groups compared to white students. It is important to note that within our study sample, 95% of students are either white, Latinx, or Black.

Across various application and admission outcomes, we find limited variations in the impacts of DE based on race/ethnicity. In terms of application outcomes, all racial groups experienced similar improvement in their likelihood of applying to highly selective institutions. Regardless of racial background, students benefit equally from DE when it comes to applying to top-tier colleges. In addition, attempting more DE credits significantly increased the likelihood of Latinx students applying to at least one moderately selective college. This effect is interestingly absent among white students, suggesting that DE might play a particularly important role in expanding college access for Latinx students.

Moving on to admission outcomes, we observe some nuanced differences by race. Black students exhibited a slightly lower admission rate to moderately selective four-year colleges due to attempting more DE credits. However, this does not seem to hinder their chances of gaining admission to highly selective institutions, as they experienced similar improvements in admission outcomes to these institutions compared to white students. Similarly, Latinx students also showed a slightly smaller increase in admission to highly selective institutions compared to Whites. While the effect is not as pronounced as it is for white students, it still indicates a positive impact of DE on college admission outcomes for Latinx students.

[Table 4 here]

Sensitivity Checks

For our primary analyses, we determined the optimal bandwidth using the bandwidth selection methods based on local polynomial RDD point estimators and inference procedures developed in Calonico et al. (2014), and Calonico et al. (2020). Additionally, we conducted several checks to assess the sensitivity of our results to different bandwidth choices. Appendix Table A3 conducts the same FRD estimations using narrower (0.15) and wider (0.25) bandwidths. Despite a few exceptions, the findings from these sensitivity checks remain qualitatively similar to the main results.

Next, we test for the sensitivity of excluding covariates from our specification. Appendix Table A4 presents results including all covariates and a model only controlling for 10th-grade cumulative GPA, a dummy variable for being above the cutoff, and an interaction of the two terms (therefore excluding any other individual characteristics). The two sets of results are generally consistent, while the estimates including the covariates are larger and more precisely estimated.

Finally, we examined if accounting for high school fixed effects, rather than adjusting for school-level characteristics as in our main model, would alter our findings. The primary reason for not adopting high school fixed effects as the primary specification is the substantial degree of freedom it would necessitate, involving the inclusion of more than 350 high school fixed effects. Nevertheless, results presented in Appendix Table A5 indicate that the outcomes remain consistent with our primary findings.

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 examines the impact of DE credits on college application and admission outcomes. Our results indicate 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 and getting admitted to more selective institutions.

Moreover, our analysis of heterogeneity reveals that additional DE credits had a similar impact on the probability of applying to the most selective colleges across all racial groups. However, DE also increased the likelihood of Latinx students applying to moderately selective institutions, a trend not observed among white students. Despite the equal improvement in application outcomes among racially marginalized groups, the benefits of DE on expanding application choices do not seem to translate into equally favorable admission outcomes for all racial groups. In fact, the improvement in admission outcomes is slightly less pronounced for Black and Latinx students compared to their white counterparts. These findings underscore a complex interplay of factors. It is possible that while DE coursework enhances the overall college application strategies of these students, it does not fully address systemic barriers that racially marginalized groups face in the college admissions process, such as racial biases in admissions or disparities in access to resources and support. Thus, our findings highlight the importance of further research to delve deeper into understanding these disparities. This investigation could shed light on the intricate dynamics at play and help formulate more targeted strategies to address the challenges faced by various racial groups in the college admissions process.

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 experiences. 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 choices by encouraging applications to more selective institutions, and that such effects are observed across students of different races and ethnicities. These 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 RDD design, our findings are based on local comparisons of students around the eligibility threshold for DE enrollment. Thus, it remains 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 examining students' complete college choice portfolios would be necessary to validate findings from the current study. Finally, since our data lack information from out-of-state colleges or in-state private colleges, it limits our ability to directly examine the impact of DE on college enrollment outcomes, which is a central aspect of the college undermatching literature. Nevertheless, recognizing that the college enrollment process begins with application and admission decisions, our examination of how DE influences students' choices in building their college application portfolio and on subsequent admission outcomes offers valuable insights into eventual enrollment decisions.

Despite these caveats, the positive impact on college application behaviors and admission outcomes identified in this study suggests that DE programs might present benefits to students beyond simply expanding college access. Future research should focus on the impact of DE on the selectivity of college enrolled and 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.

References

Ali, S. N., & Shorrer, R. I. (2021). *The college portfolio problem*. https://economics.virginia.edu/sites/economics.virginia.edu/files/Shorrer_College.pdf.

Allen, D., & Dadgar, M. (2012). Does dual enrollment increase students' success in college? Evidence from a quasi-experimental analysis of dual enrollment in New York City. *New Directions for Higher Education*, *2012*(158), 11–19. https://doi.org/10.1002/he.20010

An B. (2013). The impact of dual enrollment on college degree attainment: Do low-SES students benefit? *Educational Evaluation and Policy Analysis*, 35, 57–75. https://doi.org/10.3102/016237371246193

An, B. P., & Taylor, J. L. (2019). A review of empirical studies on dual enrollment: Assessing educational outcomes. In M. B. Paulsen & L. W. Perna (Eds.), *Higher education: Handbook of theory and research* (pp. 99–151). Springer.

Avery, C., & Goodman, J. (2022). Ability signals and rigorous coursework: Evidence from AP Calculus participation. *Economics of Education Review*, *88*, 102237. https://doi.org/10.1016/j.econedurev.2022.102237

Avery, C., & Hoxby, C. M. (2004). Do and should financial aid packages affect students' college choices? In C. M. Hoxby (Ed.), *College choices: The economics of where to go, when to go, and how to pay for it* (pp. 239–302). University of Chicago Press.

Baker, R., Klasik, D., & Reardon, S. F. (2018). Race and stratification in college enrollment over time. *AERA Open*, *4*(1). https://doi.org/10.1177/2332858417751896

Barreca, A. I., Lindo, J. M., & Waddell, G. R. (2016). Heaping-induced bias in regression-discontinuity designs. *Economic inquiry*, *54*(1), 268-293. https://doi.org/10.1111/ecin.12225

Black, S. E., Denning, J. T., & Rothstein, J. (2023). Winners and losers? the effect of gaining and losing access to selective colleges on education and labor market outcomes. *American Economic Journal: Applied Economics*, *15*(1), 26-67. https://doi.org/10.3386/w26821

Calonico, S., Cattaneo, M. D., & Farrell, M. H. (2020). Optimal bandwidth choice for robust bias-corrected inference in regression discontinuity designs. *The Econometrics Journal*, *23*(2), 192-210. https://doi.org/10.1093/ectj/utz022

Calonico, S., Cattaneo, M. D., & Titiunik, R. (2014). Robust nonparametric confidence intervals for regression-discontinuity designs. *Econometrica*, *82*(6), 2295-2326. https://doi.org/10.3982/ECTA11757

Carnevale, A. P., Van Der Werf, M., Quinn, M. C., Strohl, J., & Repnikov, D. (2018). *Our separate and unequal public colleges: How public colleges reinforce White racial privilege and marginalize Black and Latino students.* Georgetown University, Center on Education and the Workforce. https://cew.georgetown.edu/cew-reports/sustates/

Cattaneo, M. D., & Titiunik, R. (2022). Regression discontinuity designs. *Annual Review of Economics*, *14*, 821-851. https://doi.org/10.1146/annurev-economics-051520-021409

Chade, H., Lewis, G., & Smith, L. (2014). Student portfolios and the college admissions problem. *The Review of Economic Studies*, *81*(3), 971-1002. https://doi.org/10.1093/restud/rdu003

Clinedinst, M. E., Hurley, S. F., & Hawkins, D. A. (2011). *2011 state of college admission*. National Association for College Admission Counseling. https://www.thecollegesolution.com/wp-content/uploads/2011/10/NACAC-report.pdf

Cohodes, S. R., & Goodman, J. S. (2014). Merit aid, college quality, and college completion: Massachusetts' Adams scholarship as an in-kind subsidy. *American Economic Journal: Applied Economics*, *6*(4), 251–85. https://www.aeaweb.org/articles?id=10.1257/app.6.4.251

Conger, D., Long, M. C., & McGhee, Jr, R. (2023). Advanced Placement and initial college enrollment: Evidence from an experiment. *Education Finance and Policy, 18*(1), 52-73. https://doi.org/10.26300/cx24-vx18

Cowan, J., & Goldhaber, D. (2015). How much of a" running start" do dual enrollment programs provide students?. *The Review of Higher Education*, *38*(3), 425-460. https://doi.org/10.1353/rhe.2015.0018

Dale, S., & Krueger, A. B. (2011). *Estimating the return to college selectivity over the career using administrative earnings data* (No. w17159). National Bureau of Economic Research. https://www.nber.org/papers/w17159

Dillon, E. W., & Smith, J. A. (2017). Determinants of the match between student ability and college quality. *Journal of Labor Economics*, *35*(1), 45–66.

Dee, T. S., Dobbie, W., Jacob, B. A. & Rockoff, J. (2019). The causes and consequences of test score manipulation: Evidence from the New York Regents examinations. American Economic Journal: Applied Economics 11 (3), 382–423.

Evans, Brent J. How college students use advanced placement credit. *American Educational Research Journal* 56.3 (2019): 925-954. https://doi.org/10.3102/0002831218807428

Fu, C. (2014). Equilibrium tuition, applications, admissions, and enrollment in the college market. *Journal of Political Economy*, *122*(2), 225–281. https://doi.org/10.1086/675503

Giani, M., Alexander, C., & Reyes, P. (2014). Exploring variation in the impact of dual-credit coursework on postsecondary outcomes: A quasi-experimental analysis of Texas students. *The High School Journal, 97*(4), 200–218. https://doi.org/10.1353/hsj.2014.0007

Gurantz, O. (2021). How college credit in high school impacts postsecondary course-taking: The role of Advanced Placement exams. *Education Finance and Policy*, *16*(2), 233-255. https://doi.org/10.1162/edfp_a_00298

Hemelt, S. W., Schwartz, N. L., & Dynarski, S. M. (2020). Dual-credit courses and the road to college: Experimental evidence from Tennessee. *Journal of Policy Analysis and Management*, *39*(3), 686–719. https://doi.org/10.1002/pam.22180

Henneberger, A. K., Witzen, H., & Preston, A. M. (2022). A longitudinal study examining dual enrollment as a strategy for easing the transition to college and career for emerging adults. *Emerging Adulthood*, *10*(1), 225-236. https://doi.org/10.1177/2167696820922052

Hill, C. B., Winston, G. C., & Boyd, S. A. (2005). Affordability: Family incomes and net prices at highly selective private colleges and universities. *The Journal of Human Resources*, *40*(4), 769–790. https://www.jstor.org/stable/4129540

Hipolito-Delgado, C., & Lee, C. (2007). Empowerment theory for the professional school counselor: A manifesto for what really matters. *Professional School Counseling*, 10, 327–332. https://doi.org/10.1177/2156759X0701000401

Hoekstra, M. (2009). The effect of attending the flagship state university on earnings: A discontinuity-based approach. *The Review of Economics and Statistics*, *91*(4), 717–724. https://www.jstor.org/stable/25651372

Hossler, D., J. M. Braxton, and G. Coopersmith (1989). Understanding student college choice. In John C. Smart (ed.), *Higher Education: Handbook of Theory and Research*, vol. 5, pp. 231–288. New York: Agathon Press.

Hossler, D., and K. S. Gallagher (1987). Studying student college choice. A three phase model and the implications for policy makers*.* *College and University* 2(3): 207–222.

Hoxby, C. M., & Avery, C. (2013). Low-income high-achieving students miss out on attending selective colleges. *Brookings Papers on Economic Activity*.

Hoxby, C., & Turner, S. (2013). *Expanding college opportunities for high-achieving, low income students*. (SIEPR Discussion Paper No. 12-014). Stanford University, Stanford Institute for Economic Policy Research. https://siepr.stanford.edu/publications/working-paper/expanding-college-opportunities-high-achieving-low-income-students

Hugo, E. B. (2001). Dual enrollment for underrepresented student populations. *New Directions for Community Colleges*, *2001*(113), 67–72. https://doi.org/10.1002/cc.10

Jackson, C. Kirabo. 2014. Do college-preparatory programs improve long-term outcomes? Economic Inquiry 52(1): 72–99.

Karp, M. M. (2012). “I don't know, I've never been to college!” Dual enrollment as a college readiness strategy. *New Directions for Higher Education*, *2012*(158), 21–28. https://doi.org/10.1002/he.20011

Karp, M. M., Calcagno, J. C., Hughes, K. L., Jeong, D. W., & Bailey, T. R. (2007). *The postsecondary achievement of participants in dual enrollment: An analysis of student outcomes in two states.* Columbia University, Teachers College, Community College Research Center. https://ccrc.tc.columbia.edu/media/k2/attachments/dual-enrollment-student-outcomes.pdf

Klopfenstein, K., & Lively, K. (2012). Dual enrollment in the broader context of college-level high school programs. *New Directions for Higher Education*, *2012*(158), 59-68.

Klopfenstein K., Thomas M. K. (2009). The link between advanced placement experience and early college success. Southern Economic Journal, 75, 873–891.

Ison, M. P. (2022). Dual enrollment, performance-based funding, and the completion agenda: An analysis of post-secondary credential outcomes of dual enrollment students by credential type. *Community College Review*, *50*(1), 51-70. https://doi.org/10.1177/00915521211047673

Lee, J., Fernandez, F., Ro, H. K., & Suh, H. (2022). Does Dual Enrollment Influence High School Graduation, College Enrollment, Choice, and Persistence?. *Research in Higher Education*, 1-24. https://doi.org/10.1007/s11162-021-09667-3

Lichtenberger, E., Witt, M. A., Blankenberger, B., & Franklin, D. (2014). Dual credit/dual enrollment and data driven policy implementation. *Community College Journal of Research and Practice*, *38*(11), 959-979. https://doi.org/10.1080/10668926.2013.790305

Liu, V. Y. T., Minaya, V., Zhang, Q., & Xu, D. (2020). High school dual enrollment in Florida: Effects on college outcomes by race/ethnicity and course modality. Columbia University, Teachers College, Community College Research Center. https://ccrc.tc.columbia.edu/media/k2/attachments/dual-enrollment-florida-race-ethnicity-course-modality.pdf

Long M., Conger D., Iatarola P. (2012). Effects of high school course-taking on secondary and postsecondary success. American Education Research Journal, 49, 285–322.

Marken, S., Gray, L., & Lewis, L. (2013). *Dual enrollment programs and courses for high school students at postsecondary institutions: 2010-11*. (NCES 2013-002). Institute of Education Sciences, National Center for Education Statistics. https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2013002

Miller, T., Kosiewicz, H., Tanenbaum, C., Atchison, D., Knight, D., Ratway, B., Delhommer, S., & Levin, J. (2018). *Dual-credit education programs in Texas: Phase II*. American Institutes for Research. https://www.air.org/sites/default/files/Dual-Credit-Education-Programs-in-Texas-Phase-II-July-2018.pdf

Ost, B., Pan, W., & Webber, D. (2018). The returns to college persistence for marginal students: Regression discontinuity evidence from university dismissal policies. *Journal of Labor Economics*, *36*(3), 779-805.

Smith, J., Hurwitz, M., Avery, C. (2017). Giving college credit where it is due: Advanced Placement exam scores and college outcomes. *Journal of Labor Economics*, *35*(1), 67–147. https://www.journals.uchicago.edu/doi/full/10.1086/687568

Speroni, C. (2011a). *Determinants of students' success: The role of Advanced Placement and dual enrollment programs.* National Center for Postsecondary Research. https://ccrc.tc.columbia.edu/publications/role-advanced-placement-dual-enrollment.html

Speroni, C. (2011b). *High school dual enrollment programs: Are we fast-tracking students too fast?* National Center for Postsecondary Research. https://ccrc.tc.columbia.edu/publications/dual-enrollment-fast-tracking-too-fast.html

Staiger, D. O., & Stock, J. H. (1994). *Instrumental variables regression with weak instruments*. (No. 151). National Bureau of Economic Research. https://doi.org/10.3386/t0151

Stock, J. H., & Yogo, M. (2005). Testing for weak instruments in linear IV regression. In D. W. K. Andrews & J. H. Stock (Eds.), *Identification and inference for econometric models.* Cambridge University Press (pp. 80–108).

Taie, S., & Lewis, L. (2020). *Dual or concurrent enrollment in public schools in the United States*. (NCES 2020-125). Institute of Education Sciences, National Center for Education Statistics. https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2020125

Taylor, J. L. (2015). Accelerating pathways to college: The (in)equitable effects of community college dual credit. *Community College Review, 43*(4), 355–379. https://doi.org/10.1177/0091552115594880

Turner, T. A. (2019). The varied college pathways of Latino young adults: A narrative study of empowerment theory. *Professional School Counseling*, *23*(1), https://doi.org/10.1177/2156759X1987

U.S. Department of Education, Institute of Education Sciences, What Works Clearinghouse. (2017). *Transition to college intervention report: Dual enrollment programs.* Retrieved from https://ies.ed.gov/ncee/wwc/InterventionReport/671

Xu, D., Solanki, S., & Fink, J. (2021). College acceleration for all? Mapping racial gaps in Advanced Placement and dual enrollment participation. *American Educational Research Journal*, *58*(5), 954-992. https://doi.org/10.3102/0002831221991138

Zimmerman, S. D. (2014). The returns to college admission for academically marginal students. *Journal of Labor Economics*, *32*(4), 711–754. https://doi.org/10.1086/676661

Table 1

Summary Statistics of 2007 and 2012 Ninth-Grade Cohorts

Characteristics and Outcomes	All Students Mean	All Students Standard Deviation	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
Latinx	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
% Latinx	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
Applied to any four-year schools	0.27	(0.33)	0.21	0.53
Applied to at least a moderately selective four-year school	0.11	(0.32)	0.08	0.26
Applied to at least a highly selective four-year school	0.35	(0.76)	0.26	0.76
Admitted to any four-year schools	0.20	(0.40)	0.15	0.43
Admitted to at least a moderately selective four-year school	0.20	(0.29)	0.15	0.44
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

Table 2
Balance Check of Student Demographics at Cutoff

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Female	White	Black	Latinx	FRPL students	LEP students	Grade 9 GPA	Grade 9 credits earned
Panel A. Excluding Other Covariates								
DE credits	-0.0231	0.0224	-0.0218	0.0018	0.0121	-0.0161	-0.0051	-0.0684
	(0.0151)	(0.0368)	(0.0140)	(0.0334)	(0.0118)	(0.0273)	(0.0052)	(0.1859)
Observations	21,218	21,218	21,218	21,218	21,218	21,218	21,218	21,218
R-squared	0.001	0.003	0.002	0.001	0.004	0.001	0.192	0.000
Panel B. Including Other Covariates								
DE credits	-0.0236	0.0006	0.0004	0.0006	0.0153	-0.0258**	-0.0055	-0.0423
	(0.0151)	(0.0010)	(0.0010)	(0.0010)	(0.0099)	(0.0116)	(0.0039)	(0.1637)
Observations	21,218	21,218	21,218	21,218	21,218	21,218	21,218	21,218
R-squared	0.016	0.997	0.994	0.996	0.248	0.245	0.244	0.070

Note. Each cell represents a separate linear 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, Latinx, or other races; who have LEP status, FRPL status, and American citizenship; and who were born in a certain year), except when the specific characteristics are used as the outcome in the regression. Observations right at the cutoff of cumulative GPA 3.0 are excluded from this analysis. Standard errors are in parentheses. ***p < 0.001. **p < 0.01. *p < 0.05.

Table 3

Impacts of DE on Application and Admission Outcomes to Four-Year Colleges using Donut Hole Strategy (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	0.0278	0.0078	0.0114*	0.0120**
	(0.0227)	(0.0092)	(0.0063)	(0.0055)
Fuzzy regression discontinuity estimates	0.1608	0.0452	0.0661	0.0693*
	(0.1326)	(0.0496)	(0.0416)	(0.0409)
Mean	0.5951	0.3369	0.3011	0.0878
N	21,218	21,218	21,218	21,218
	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				
Intent-to-treat estimates	0.0103	0.0067	-0.0010	0.0068*
	(0.0159)	(0.0092)	(0.0066)	(0.0033)
Fuzzy regression discontinuity estimates	0.0594	0.0391	-0.0055	0.0392**
	(0.0865)	(0.0494)	(0.0376)	(0.0181)
Mean	0.3291	0.2076	0.1973	0.0382
N	21,218	21,218	21,218	21,218

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, Latinx, 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. Observations right at the cutoff of cumulative GPA 3.0 are excluded from this analysis. ***$p < 0.001$. **$p < 0.01$. *$p < 0.05$.

Table 4

Heterogeneous Impacts of DE on Application and Admission Outcomes to Four-Year Colleges using Donut Hole Strategy (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: 21, 218)*				
FRD estimates	0.1372	0.0286	0.0431	0.0715***
	(0.0883)	(0.0346)	(0.0291)	(0.0237)
FRD estimates * Black	0.1947	0.0304	0.0873	0.0949**
	(0.1961)	(0.0812)	(0.0838)	(0.0411)
FRD estimates * Latinx	0.0117	-0.0641	-0.0744	0.0891*
	(0.1594)	(0.0677)	(0.0631)	(0.0479)
	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: 21, 218)*				
FRD estimates	0.0688	0.0195	0.0237	0.0485***
	(0.0656)	(0.0381)	(0.0291)	(0.0151)
FRD estimates* Black	0.1337	0.0153	0.1415*	0.0527*
	(0.1344)	(0.0737)	(0.0777)	(0.0296)
FRD estimates * Latinx	0.0403	-0.0384	-0.0083	0.0915***
	(0.1052)	(0.0647)	(0.0604)	(0.0342)

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, Latinx, 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. Observations right at the cutoff of cumulative GPA 3.0 are excluded from this analysis. ***p < 0.001. **p < 0.01. *p < 0.05.

Figure 1

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

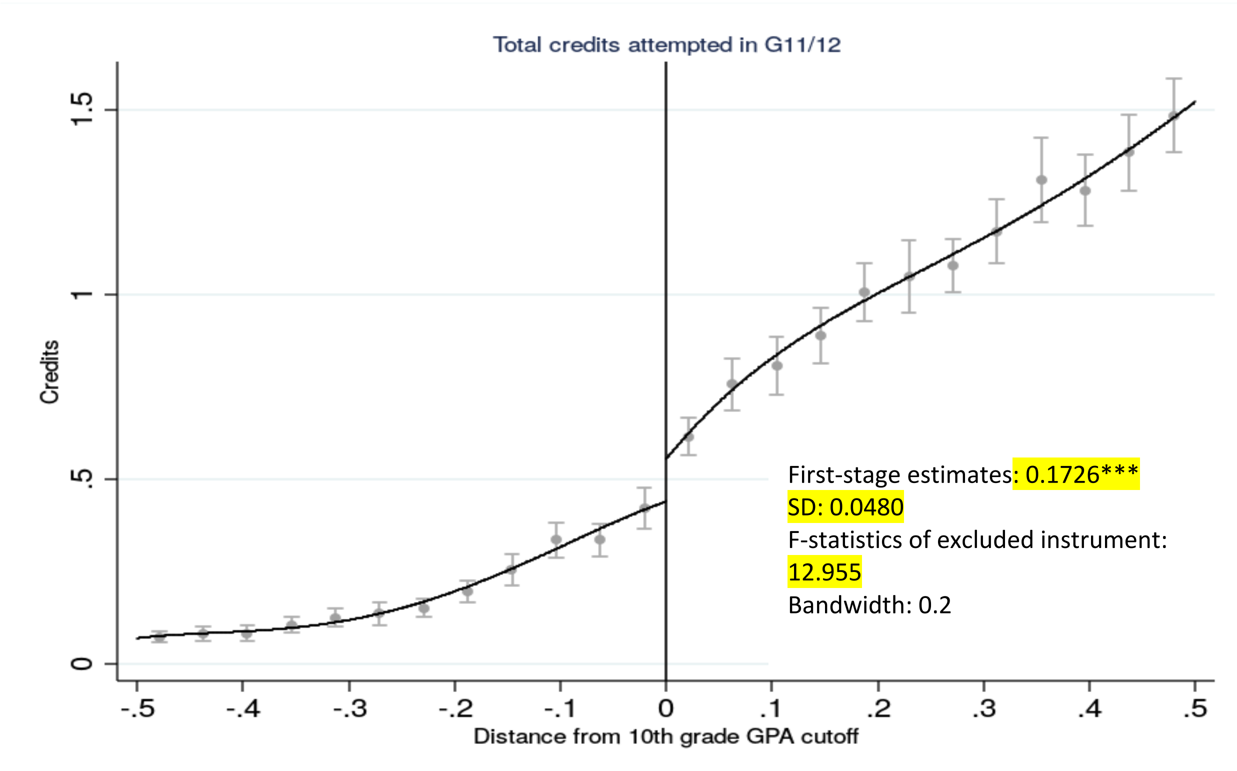

Figure 2

RD Validity Check: Density of Observation Around Cutoff

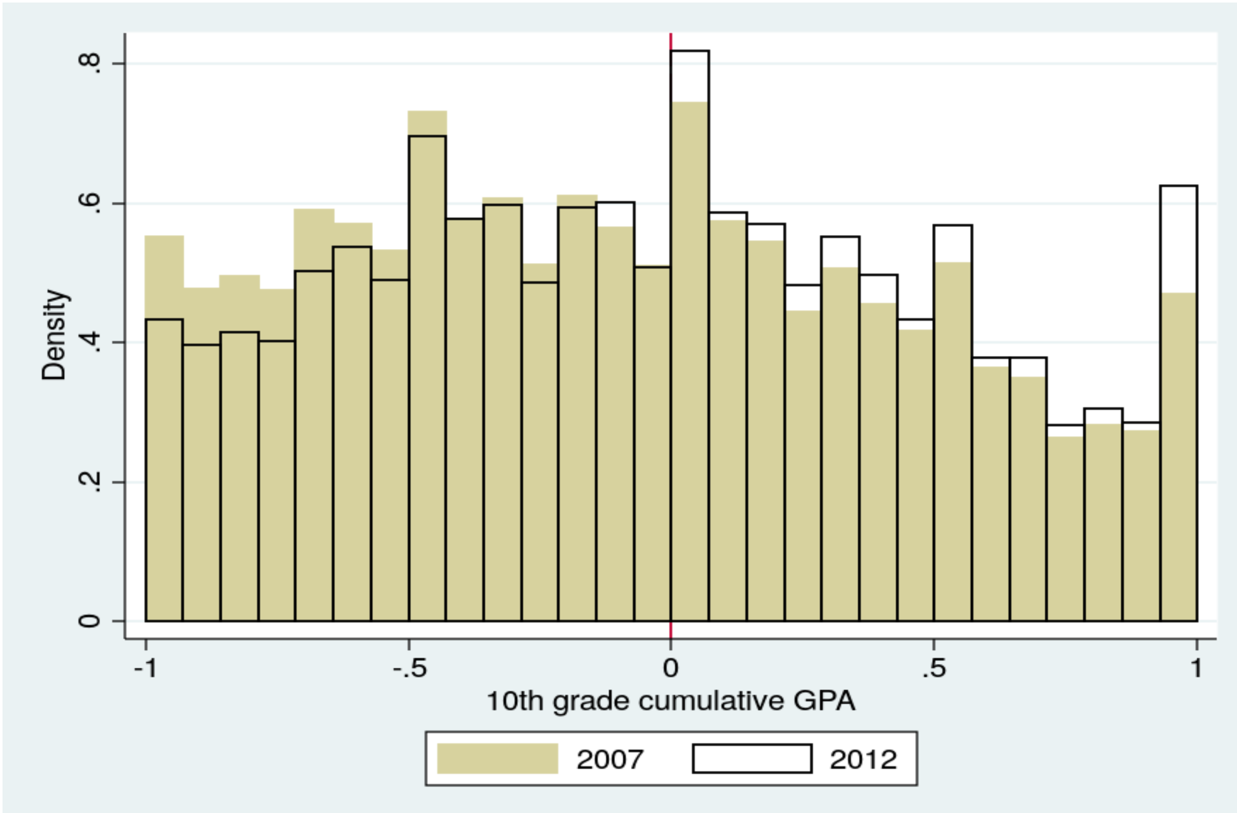

Figure 3

Ratios of Conditional to Unconditional Grade Densities by Distance to DE GPA Cutoff

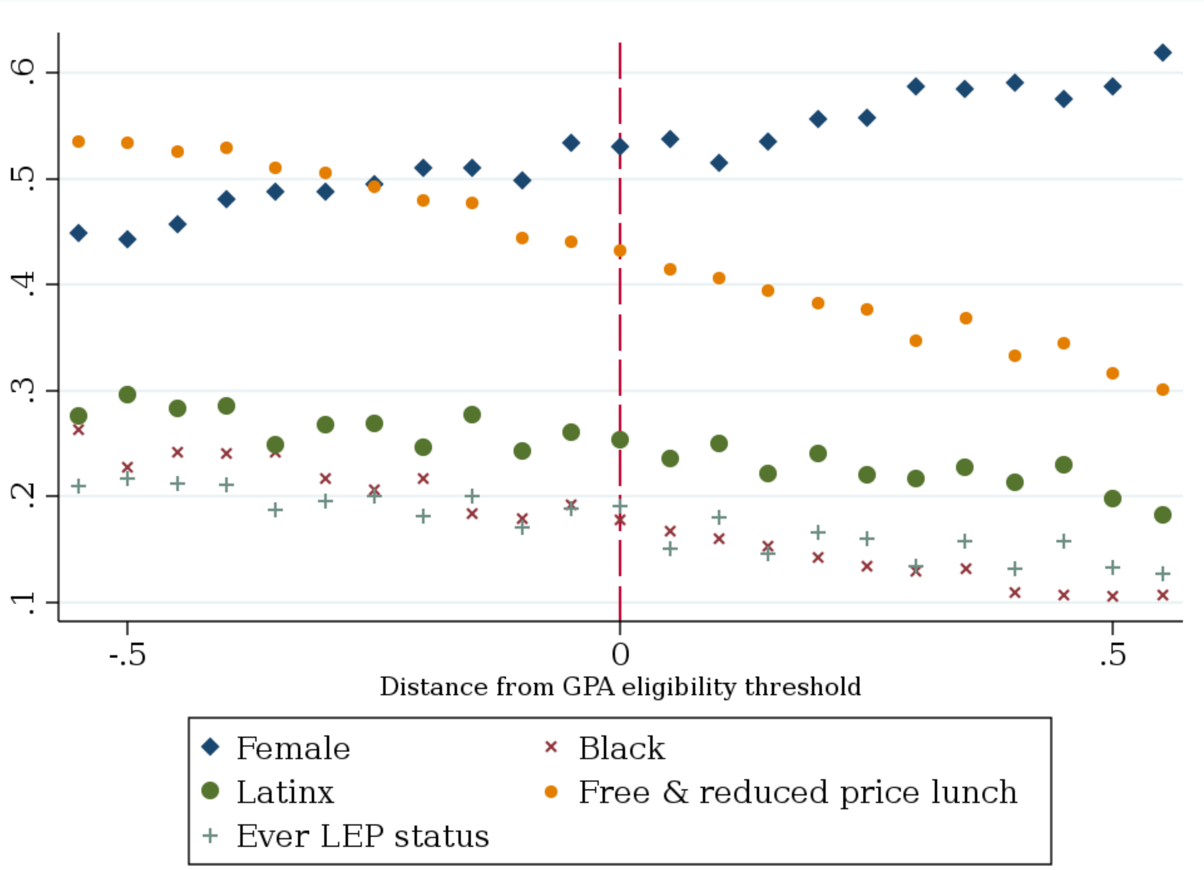

Figure 4

RD Validity Check: 10^{th}-Grade Cumulative GPA Distribution by Student Demographics

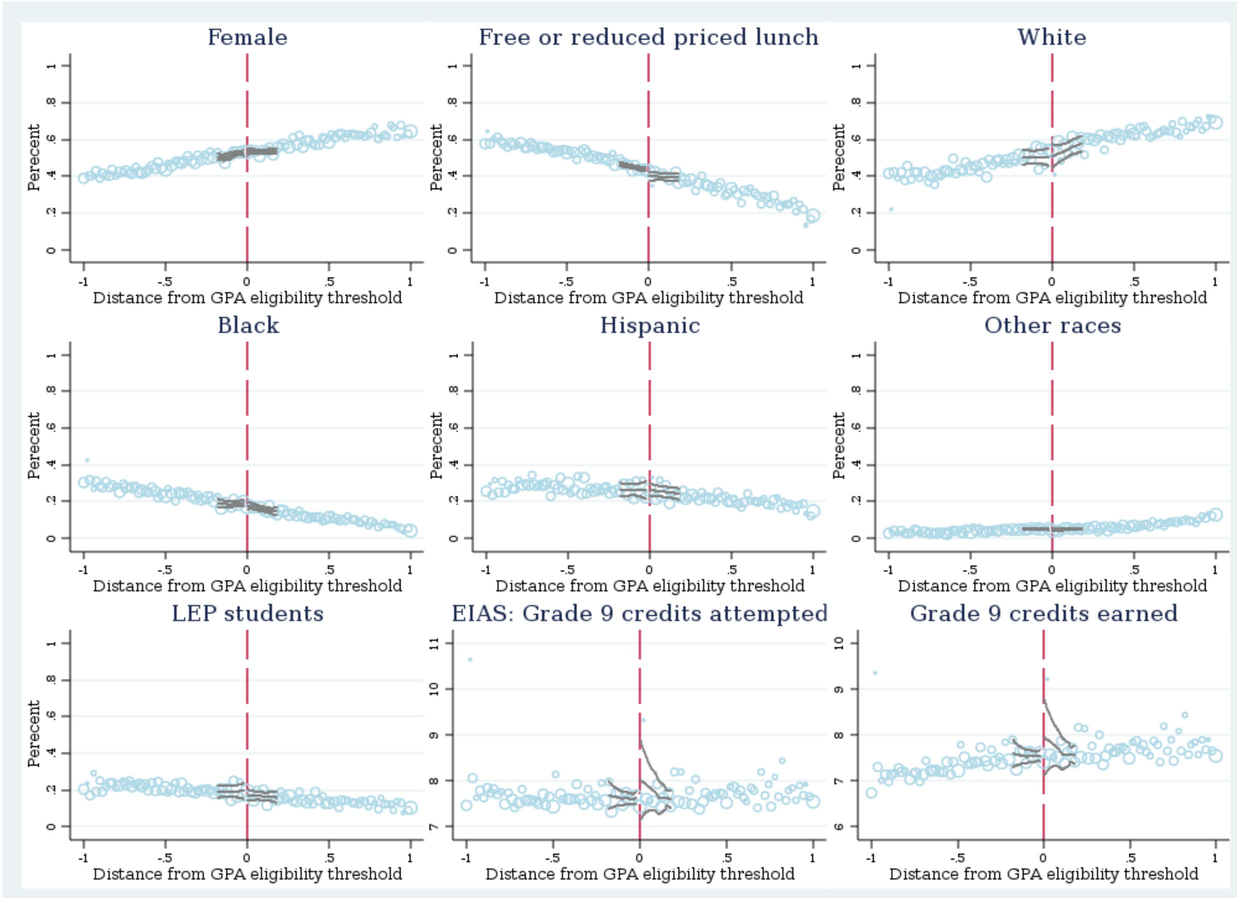

Figure 5A

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

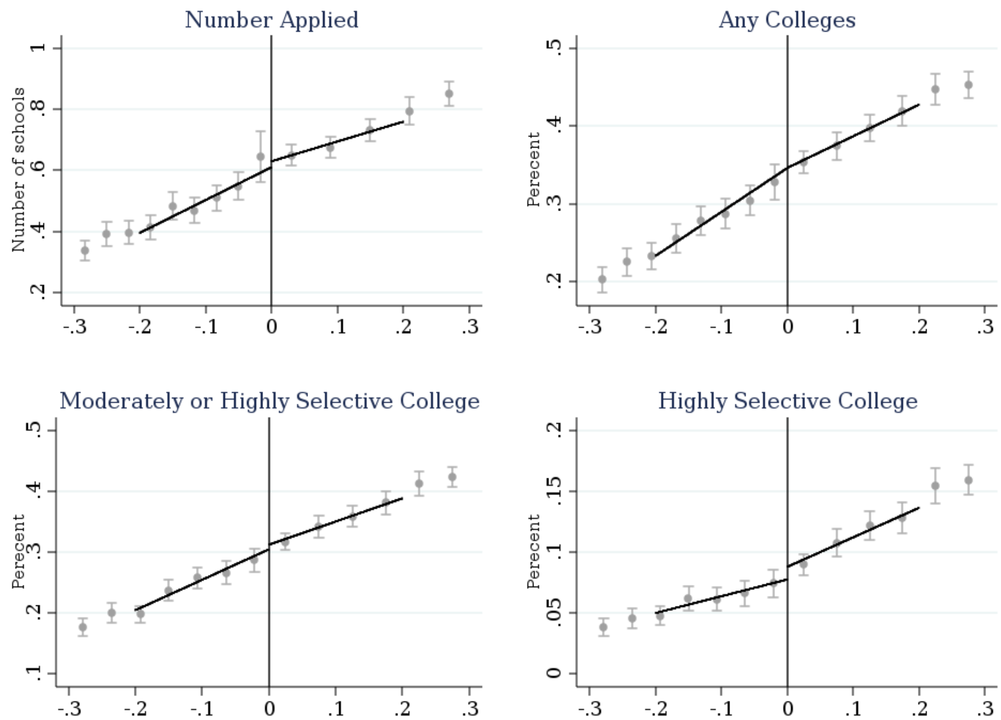

Figure 5B

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

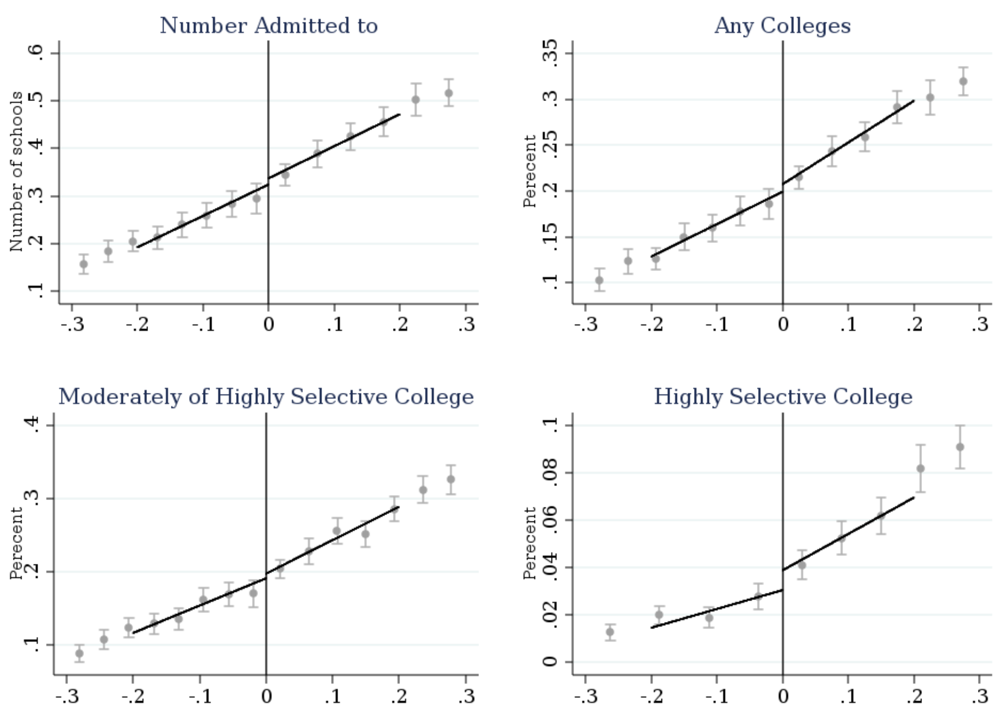

Figure Captions

Figure 1

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

Caption: Figure 1 presents the average of the cumulative number of DE credits attempted in grades 11 and 12 for students scoring above and below the 10th-grade GPA cutoff for our analytic sample.

Figure 2
RD Validity Check: Density of Observation Around Cutoff

Caption: Figure 3 shows the number of observations at each 10th grade cumulative GPA by 0.07 GPA bin by cohort. The x-axis is center to the cutoff at 3.0 GPA.

Figure 3

Ratios of conditional to unconditional grade densities by distance relative to the DE GPA cutoff for five different conditioning groups: Female students, Black students, Latinx students, students who have free or reduced-price lunch, and students who ever has a LEP status. Densities are computed with bins with a width of .05 grade points.

Figure 4
RD Validity Check: 10th-Grade Cumulative GPA Distribution by Student Demographics

Caption: Figure 2 shows the average value of each individual characteristic at the 0.03 GPA bin. The x axis is the GPA distance from the DE cutoff (3.0) and the dotted vertical line represents the GPA cutoff. The three lines around the dotted line are the local weighted regression of each variable on the GPA distance from the cutoff within bandwidth and the confidence interval respectively.

Figure 5A
Number of Four-Year Colleges Applied to and the Highest Selectivity of Four-Year Colleges Applied to by 10th-Grade GPA

Caption: Figure 5A presents the average of each of the application outcomes for students scoring above and below the 10th-grade GPA cutoff for our analytic sample.

Figure 5B
Number of Four-Year Colleges Admitted to and Highest Selectivity of Four-Year Colleges Admitted to by 10th-Grade GPA

Caption: Figure 5B presents the average of each of the admission outcomes for students scoring above and below the 10th-grade GPA cutoff for our analytic sample.

Appendix

Sample Restriction

The details of our sample restriction are highlighted in Table A1 Panel A. 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. While the state recommends a cumulative GPA of 3.0 as the minimum requirement, anecdotal evidence and focus group conversations have shown that this eligibility requirement is not strictly enforced, especially in smaller schools. In some schools, a positive recommendation letter allows a student with a GPA below the requirement to DE. To separate schools that are compliant with this GPA requirement, 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. Panel B presents the school level characteristics of students' demographics and academic performance. It shows that schools with high DE eligibility non-compliant rate share similar student characteristics as those that remain in the sample.

Next, we excluded 10,473 students without any 9^{th}- and 10^{th}-grade high school transcripts as they might 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.

Table A1
Sample Restriction and Size

Panel A: 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 9th- and 10th-grade records	120,868
Exclude students with DE before 11th grade	115,413
Within 0.2 bandwidth from the 3.0 GPA cutoff	23,303

Panel B: Comparison Analytical Sample to Schools with High Noncompliant rate	Analytical Sample	Out of sample
% Female	50%	50%
% Black	19%	23%
% Latinx	24%	26%
% Asian/Pacific islander/Hawaiian	3%	4%
% American Indian	0%	0%
% Other races	5%	6%
% Free or reduced priced lunch	45%	48%
% LEP students	18%	21%
% State Resident	99%	100%
% US citizen	88%	86%
Average Grade 12 GPA	2.83	2.83
Average Grade 12 credits attempted	7.13	6.91
High School Graduation Rate	85%	86%
Enrollment	1045	737
School level Outcomes		
Number of four-year schools applied to	0.53	0.64
Number of four-year schools admitted to	0.35	0.39
Applied to any four-year schools	29%	32%
Applied to at least a moderately selective four-year school	27%	29%
Applied to at least a highly selective four-year school	11%	13%
Admitted to any four-year schools	20%	21%
Admitted to at least a moderately selective four-year school	20%	21%
Admitted to at least a highly selective four-year school	8%	9%

Table A2

Impacts of DE on Application and Admission Outcomes to Four-Year Colleges using Donut Hole Strategy and Wald Estimator (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				
Fuzzy regression discontinuity estimates	0.1608	0.0452	0.0661	0.0693*
	(0.1326)	(0.0496)	(0.0416)	(0.0409)
Wald estimates	0.1608	0.0452	0.0661	0.0693*
	(0.1390)	(0.0550)	(0.0406)	(0.0370)
Mean	0.5951	0.3369	0.3011	0.0878
N	21,218	21,218	21,218	21,218
	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				
Fuzzy regression discontinuity estimates	0.0594	0.0391	-0.0055	0.0392**
	(0.0865)	(0.0494)	(0.0376)	(0.0181)
Wald estimates	0.0594	0.0391	-0.0055	0.0392*
	(0.0925)	(0.0546)	(0.0382)	(0.0221)
Mean	0.3291	0.2076	0.1973	0.0382
N	21,218	21,218	21,218	21,218

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, Latinx, 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. Observations right at the cutoff of cumulative GPA 3.0 are excluded from this analysis. ***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	0.0733	0.0348	0.0566	0.0138
N = 15,895	(0.1214)	(0.0525)	(0.0442)	(0.0302)
	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	0.0094	0.0509	0.0243	0.0114
	(0.0771)	(0.0454)	(0.0416)	(0.0183)
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	0.1025	0.0346	0.0454	0.0456*
N = 28,645	(0.1024)	(0.0399)	(0.0321)	(0.0236)
	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	0.0639	0.0506	0.0194	0.0122
	(0.0639)	(0.0318)	(0.0261)	(0.0163)

Note. Panels A and B include estimates using a 0.15 GPA bandwidth while Panel C & D contain samples within 0.25 GPA bandwidth. Each cell represents a separate regression and 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, Latinx, or other races; who have LEP status, FRPL status, and American citizenship; and who were born in a certain year). Observations right at the cutoff of cumulative GPA 3.0 are excluded from this analysis. Standard errors are in parentheses. ***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	0.0750	0.0051	0.0383	0.0559
	(0.1972)	(0.0728)	(0.0844)	(0.0497)
With Covariates	0.1608	0.0452	0.0661	0.0693*
	(0.1326)	(0.0496)	(0.0416)	(0.0409)
Mean	0.5951	0.3369	0.3011	0.0878
N	21,218	21,218	21,218	21,218

	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	0.0236	0.0188	-0.0193	0.0345*
	(0.1098)	(0.0654)	(0.0503)	(0.0196)
With Covariates	0.0594	0.0391	-0.0055	0.0392**
	(0.0865)	(0.0494)	(0.0376)	(0.0181)
Mean	0.3291	0.2076	0.1973	0.0382
N	21,218	21,218	21,218	21,218

Note. Each cell represents a separate regression within a 0.2 GPA band width. Each cell is a separate regression. When covariates are included, the regression controls 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, Latinx, or other races; who have LEP status, FRPL status, and American citizenship; and who were born in a certain year. Observations right at the cutoff of cumulative GPA 3.0 are excluded from this analysis. Standard errors are in parentheses. ***p < 0.001. **p < 0.01. *p < 0.05.

Table A5

Impacts of DE on Application and Admission Outcomes using High School Fixed Effect (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				
Fuzzy regression discontinuity estimates	0.1478	0.0438	0.0692	0.0701
	(0.1402)	(0.0513)	(0.0427)	(0.0432)
Mean	0.5988	0.3377	0.3021	0.0879
N	20,843	20,843	20,843	20,843
	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				
Fuzzy regression discontinuity estimates	0.0432	0.0214	-0.0239	0.0390**
	(0.0993)	(0.0467)	(0.0410)	(0.0175)
Mean	0.3306	0.2080	0.1982	0.0385
N	20,843	20,843	20,843	20,843

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