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CTE-Focused Dual Enrollment: Participation and Outcomes

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CTE-focused Dual Enrollment: Participation and Outcomes

INTRODUCTION

Dual enrollment and Career and Technical Education (CTE) have their respective origins in different paradigms for educational advancement. Dual enrollment—or the college courses that are taken while a student is still in high school—was initially conceptualized as a way for college-bound students to get more rigorous educational opportunities. On the opposite side, CTE, originally called vocational education, was intended to provide students who were not bound for college an educational alternative that would allow them to directly enter the workplace (Giani, 2022). As CTE has expanded its focus to include more high-skill jobs, there has been increasing attention paid to combining these two models and providing CTE students with access to dual enrollment courses. There is very little research, however, on CTE dual enrollment with limited data on participation and only two studies that attempted to look at the impact of CTE dual enrollment.

This paper is the first study to look specifically at a statewide initiative on CTE dual enrollment, the CTE Pathway in Career and College Promise (CCP), North Carolina's dual enrollment program. In this paper, we examine the characteristics of students participating in CTE dual enrollment courses in North Carolina as well as the effect of program participation on students' high school outcomes and their enrollment in postsecondary education. We also examine the way in which outcomes differ for students who are members of different populations.

LITERATURE REVIEW

Dual enrollment, or the opportunity for students to take college courses in high school, has been in place for several decades and was originally considered as a way of increasing the rigor of the high school experience and preparing students for college. Dual enrollment has also been seen as a way of exposing traditionally non-college-bound youth to the idea of college, improving students' motivation and aspirations to attend college, and potentially reducing the costs to attend college (Bailey and Karp 2003). In dual enrollment, the courses are offered by a postsecondary institution that then awards credit upon successful completion of the courses.[1] There has been a dramatic increase in participation over the past 20 years with currently over a third of students taking some dual enrollment courses by the time they graduate (National Center for Education Statistics 2019), although there is evidence that this expansion is primarily occurring among White and more academically prepared students (Pierson, Hodara, and Luke 2017).

The current CTE movement has its origins in vocational education, which has been in place for over a century; 1917 marked the first federal act authorizing funding for vocational education. Vocational education's original intent was to ensure that students, particularly those who were low-income, immigrants, or members of other marginalized groups, were prepared for careers that did not need a postsecondary credential, including agriculture, industrial trades, and home economics. This approach has shifted in the last 40 years with an increasing emphasis on combining career and academic skills leading to a "current, more inclusive definition—preparing all students for college and career" (Kim, Flack, Parham, and Wohlstetter 2021, 358). CTE programming is widely available with 98% of school districts offering CTE programs at the high school level (Gray and Lewis 2018).

[1] There are many different terms for this, including dual credit (where students earn both high school and college credit for the same course) and concurrent enrollment (where students are taught college courses by accredited high school teachers). We use dual enrollment as the broadest umbrella term to cover all situations where students are taking college courses while in high school.

Tech-Prep, an educational strategy that was codified into law under the Carl D. Perkins Vocations and Technical Education Act, represented the first significant formal attempt to merge dual enrollment and CTE courses. Tech Prep was a sequenced program of study combining high school and college with programs intended to lead to an associate degree or a technical credential. This initiative helped create the idea of "articulated" credits where high schools and colleges formed partnerships so that students could earn college credit for high school CTE courses if the student enrolled in the partner college. According to a national study, only 15% of Tech Prep participants actually received these articulated credits (Hershey et al. 1998); for the remaining students, these courses would have provided only high school credits. Results from a study of the impact of Tech-Prep found that it increased enrollment in two-year institutions but had no overall impact on postsecondary enrollment because it reduced enrollment in four-year institutions (Cellini 2006).

The efforts to combine CTE and dual enrollment have continued and the revised Perkins IV legislation authorizing federal CTE programs required that "all career technical education (CTE) programs offer secondary to postsecondary programs of study (POS), which integrate rigorous academics, offer dual enrollment options, and lead to an industry-recognized degree or credential" (Alfeld and Bhattacharya 2013, i). According to recent data collected by NCES, 73 percent of districts offer CTE courses where students can earn both high school and postsecondary credits (Gray and Lewis 2018) although this summary does not distinguish how many of these were articulated credits that would only be awarded if a student decided to attend the local partner postsecondary institution.

Despite the apparent prevalence of CTE dual enrollment, there is very limited research on who participates and on its impacts. Indeed, there are no national statistics on how many students take CTE dual enrollment courses and the characteristics of those students, although participation levels are available for some individual states. These statistics suggest that enrollment levels differ substantially by state. For example, about 7 percent of Texas' dual enrollment courses are CTE-focused (Miller et al. 2017). On the other hand, 62 percent of Indiana's high school graduates who earned college credit had earned at least some credit in a technical area (Indiana Commission for Higher Education 2021).

There is similarly little literature on the impacts of CTE dual enrollment. Most studies look at the impact of dual enrollment but do not specifically break out findings for CTE dual enrollment. One study, which used regression analysis on data from Florida and New York City looked at the performance of CTE students who were taking dual enrollment courses, although they did not look specifically at CTE dual enrollment courses. The study found positive relationships between dual enrollment participation and high school graduation and enrollment and persistence in postsecondary education for both non-CTE and CTE students (Karp et al. 2007). Another study looked at the impact of a specific effort to combine CTE and dual enrollment, the California-based Concurrent Courses Initiative. This program integrated dual enrollment into existing CTE high school courses of study and supplemented it with extensive supports. Participants in this initiative were more likely to be male (55%), Hispanic (45% compared to 37% for White students), and likely to have parents who had some college. This study looked at results for eight sites, using both regression and propensity score analyses and found that participants had increased high school graduation rates and persistence in four-year institutions compared to similar non-participating students (Rodriguez, Hughes, and Belfield 2012).

One model that is currently gaining traction is an approach that combines the early college—a design that merges high school and college so that students can simultaneously earn a high school diploma and an associate degree or two years of college credit—with workforce partnerships. This is exemplified by P-TECH, a high school model that gives students the opportunity to earn industry-recognized postsecondary credentials while also gaining work experience. Early results from an experimental study in New York City found that P-Tech students earned more credits and passed more Regents exams (Rosen et al. 2020). This whole-school approach, while definitely promising, represents a very small proportion of students taking CTE dual enrollment courses.

It is important to note that both the fields of CTE and of dual enrollment individually have rigorous studies that have found positive impacts for specific settings. Within the CTE field, there have been randomized controlled trials of the impact of CTE Academies (Kemple and Scott-Clayton, 2004) and CTE-focused high schools (Hemelt, Lenard and Paeplow, 2019) as well as regression discontinuity studies of stand-alone CTE high schools in the northeast (Brunner, Dougherty and Ross 2021; Dougherty 2018). Around dual enrollment, there are two lottery-based experimental studies that look at the impact of early colleges, a whole school model in which dual enrollment plays a significant role (Edmunds et al, 2020; Song and Kaiser 2021). Although these studies have strong internal validity, it is important to note that both sets of studies look at schools or academies within schools, very specific settings that do not represent the vast majority of CTE or dual enrollment experiences. Thus, there are open questions about the extent to which findings from these studies are applicable to the more typical CTE or dual enrollment experience of individual courses taken in a regular high school. Our study addresses this concern by looking at CTE dual enrollment in the context of the comprehensive high school, the way in which the majority of students experience it.

Our study is thus of one of only a small handful of studies to look at participation and outcomes in CTE dual enrollment and is the first study to look at a statewide CTE dual enrollment initiative. This study adds to the very limited research on CTE dual enrollment by examining the characteristics of students participating in a statewide CTE dual enrollment pathway and by providing an examination of how student outcomes relate to participation in this CTE dual enrollment pathway.

NORTH CAROLINA'S CTE DUAL ENROLLMENT PATHWAY

Career and College Promise (CCP) is North Carolina's dual enrollment program. North Carolina began providing high school students access to college courses in 1983. In 2005, North Carolina expanded this work by authorizing and funding the formation of early colleges (called Cooperative Innovative High Schools in the state), small schools that operate in conjunction with higher education partners with the goal of providing students with both a high school diploma and associate degree or two years of college credit. By 2010, approximately 24,000 students were enrolled in some version of dual enrollment in North Carolina. At that point, both the North Carolina Community College System and the North Carolina General Assembly became concerned about clarifying varying state statutes (Jordan 2010) and ensuring that students were successful in and benefiting from these courses. The Career and College Promise legislation was passed in 2011 to address some of these concerns. The program consolidated the different authorizing legislation for North Carolina's dual enrollment programs and, in the process, made two primary changes. First, it created three distinct pathways—each with different goals and desired outcomes—to ensure that students focused their course-taking and, second, it codified eligibility criteria for students to participate in the pathways.

The CTE Dual Enrollment Pathway is for students who would like to earn a postsecondary technical credential (certificate or diploma), or college credit aligned with career clusters. It is primarily for high school juniors and seniors with eligible ninth and 10th grade students able to participate in a limited set of programs such as engineering. Eligibility for participation in the pathway differs by grade but includes an academic criterion (a 3.0 weighted GPA[2] or the approval of the principal), and the need to be informed about the pathway requirements. Students must continue to meet eligibility criteria to continue to participate in the pathway. To distinguish the CCP CTE Pathway from CTE pathways that contain high school-level courses, we refer to this pathway as the CTE Dual Enrollment Pathway.

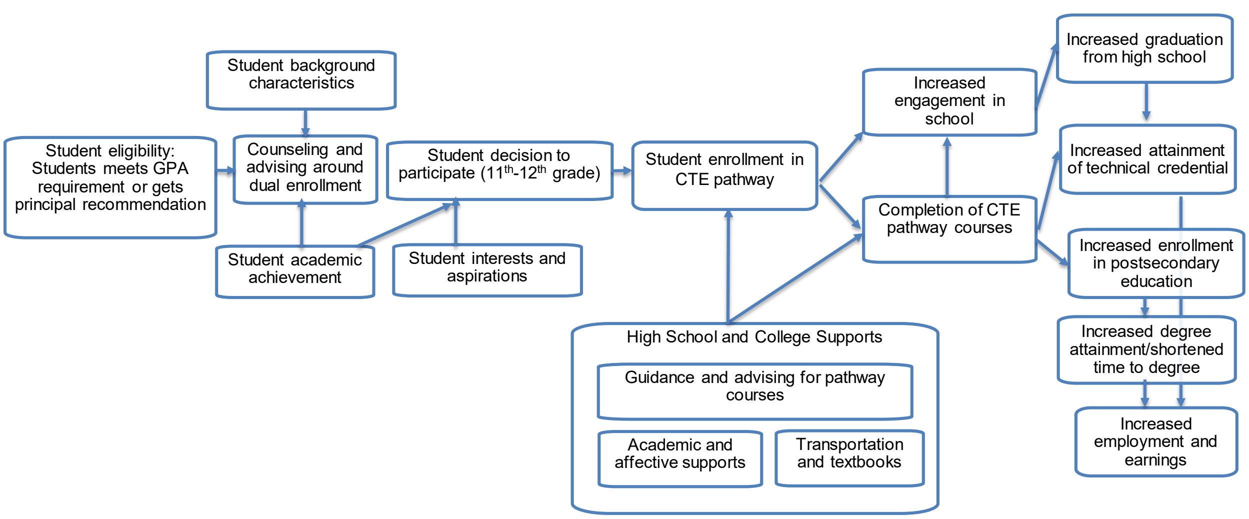
The two other CCP pathways include the College Transfer Pathway, which is designed for students who would like to continue their academic career at a four-year institution. This pathway includes college credit transfer courses in English, mathematics and a college transfer success course and has the strictest eligibility criteria. The third pathway is the Cooperative Innovative High School Pathway (CIHS), known elsewhere in the country as early colleges. Cooperative Innovative High Schools are small schools of choice, frequently located on college campuses, that provide students with the opportunity to complete an associate degree program or earn up to two years of college credit within five years. For all three pathways, the college courses are provided tuition-free; for the CTE and College Transfer pathways, costs of textbooks, fees, and transportation must be borne by either the student or the school/district, depending on decisions made at the local level. We are conducting impact and implementation studies for these other two pathways as well and those results will be presented elsewhere.

[2] In the 2019-20 school year, the GPA eligibility criterion changed to a 2.8 unweighted GPA but the 3.0 weighted GPA criterion was in place for all of the other analysis years included in this article.

The Career and College Promise legislation became effective on January 1, 2012 with 2012-2013 representing the first academic year in which the revised legislation was fully implemented, although the Cooperative Innovative High Schools Component had been in place since 2006. CCP is overseen by collaborative teams that include membership from the North Carolina Department of Public Instruction (NCDPI), the North Carolina Community College System, the University of North Carolina (UNC) System and the North Carolina Independent Colleges and Universities. Each agency is responsible for providing necessary support as aligned to their specific role. The North Carolina Community College System has articulated a set of operating procedures that defined the different pathways and clarified eligibility criteria ("Curriculum Procedures Reference Manual: Career and College Promise" 2017) while NCDPI provides guidance and technical support.

Students who enroll in the CTE pathway take courses that are intended to lead toward a certification, technical credential or major. Figure 1 presents a logic model for the CTE Dual Enrollment Pathway. This logic model drives our research questions and study design.

Figure 1: CTE Dual Enrollment Pathway Logic Model



METHODS

This paper seeks to demonstrate the relationship between participation in the CTE Dual Enrollment Pathway and secondary and postsecondary outcomes. The specific research questions driving this paper include:

1. What are the characteristics of students participating in North Carolina's CTE Dual Enrollment Pathway?
2. Do high school outcomes including graduation rates, GPA, and college credits earned in high school differ between students participating in the CTE Dual Enrollment Pathway and similar non-participating students?
3. Do rates of enrollment in postsecondary education differ between students participating in the CTE Dual Enrollment Pathway and similar non-participating students?
4. To what extent do results differ by student characteristics such as gender; race/ethnicity; and economically disadvantaged status?

Research Design

This study is part of a practitioner-researcher partnership funded by a grant from the Institute of Education Sciences. The primary partners include the North Carolina Department of Public Instruction, the North Carolina Community College System, the University of North Carolina at Greensboro, and the RAND Corporation. Other collaborators include the University of North Carolina System and the North Carolina Education Research Data Center at Duke University. The project is looking at the impact, implementation, and cost of the three North Carolina dual enrollment pathways.

One of the goals of the partnership was to determine the outcomes for students participating in the CTE Dual Enrollment Pathway. The most rigorous approach to assessing causal impact would be a randomized controlled trial (RCT), in which students would have been randomly assigned to participate in CTE dual enrollment or not. This would ensure that the students in both groups were similar to each other on both observable and unobservable characteristics and would lead to an unbiased estimate of the treatment effect. However desirable, RCTs are often not possible in policy evaluations for a variety of reasons, including ethical reasons, situations where policies are rolled out at a state-level giving all potential sample members access to the intervention at the same time or where a policy is being assessed retroactively without manipulation of the intervention.

Although our goal was to determine the causal impact of CTE dual enrollment, our situation did not allow an RCT for several reasons. First, CCP is a statewide initiative and was rolled out across the state at the same time; therefore, all students in the state operated under the same policy. That being said, there were differences in levels of access across schools in the state, differences that we attempt to leverage in our analyses. A second reason is that CCP was evaluated retroactively giving us no ability to actively manipulate the implementation of dual enrollment. We therefore needed to use a quasi-experimental approach that did not rely on randomization and was appropriate for our context but nevertheless sought to rule out as many alternative threats to causal interpretation as possible (Shadish, Cook and Campbell 2002).

In the absence of a simple setting for causal inference, we chose to use a propensity score weighting approach in which CTE Dual Enrollment Pathway participants (treatment group) were compared to non-pathway participants (comparison group) who were statistically weighted to resemble the pathway participants. This approach has many benefits over simple descriptive comparisons of students in the treated (CTE) group and comparison students because it accounts for the observable dimensions of selection bias. This approach has also been used to assess the impact of similar policy initiatives (e.g., An 2013; de Amesti and Claro 2021) and has been shown to substantially reduce, and in some cases completely eliminate selection bias, when used with covariates that are good predictors of outcome measures or selection into treatment (Cook et al., 2008 and Wong et al., 2017). While we use a rich set of covariates that we expect to do a good job of predicting CTE participation and our outcomes of interest, we also acknowledge it has some limitations and could produce biased effects in the presence of unobserved confounders. (Dhejia and Whaba 2002). To help address these limitations, we include robustness checks that examine the extent to which our estimates vary based on the set of fixed effects we include. We also estimate the Oster Bounds for our effects under different assumptions of unobserved selection. Below we describe what we view the most likely sources of selection bias into the CTE pathway and how we attempt to address them.

Given that students were not randomized, we would expect that participants and non-participants would differ based on a range of contextual and individual factors and we designed the study to account for those factors as much as possible. One of the key contextual factors that may have affected students' participation in dual enrollment was whether the school provided access to the courses. Our data show that virtually every high school in the state provides some dual enrollment but the level of participation varies dramatically with some schools having low participation and other schools having very high participation. We have seen that participation varies by locale with the average rural school having much higher levels of participation than the average urban or suburban schools. We have also found that participation differs by the level of underrepresented minority students, with lower-participating schools having higher enrollment of underrepresented minority students. As a result, we included relevant school-level covariates in our analyses including urbanicity (locale) and percentage of underrepresented minority students as well as other school-level factors such as size, charter status, county economic tier, and school-level averages of all student-level covariates. We supplement our primary analyses with a school fixed-effects analyses, which indicate very similar results.

Participating and non-participating students may also differ from each other on individual characteristics such as student achievement, background characteristics and factors such as motivation and interest. To address concerns about these possible differences, the non-pathway participants were weighted to closely resemble the participating students using a broad suite of student-level and school-level pre-treatment (i.e., measured prior to grade 11) covariates. Because dual enrollment students often have higher academic performance than non-participating students (Miller, 2017), we included measures of academic performance such as baseline test scores (reading, math, and science in 8th grade and English I and Algebra I in 9th grade) as well as GPA in 9th and 10th grade. There are certain populations more likely to take dual enrollment courses, including white and female students (An and Taylor 2019); therefore, we included gender and demographic characteristics (race/ethnicity and economically disadvantaged status). Our analyses also showed differential participation rates for students identified as gifted, English Language Learners or as students with disabilities and those factors are included as covariates.

The primary concern is that there will be different levels of interest and motivation between students participating and not participating in dual enrollment. It might be reasonable to expect that participating students might be more academically motivated, might be more interested in attending some form of postsecondary education, or particularly for CTE students, might be more interested in specific topics or careers. To capture potential academic motivation and career interest, we used measures of 9th and 10th grade coursetaking including the number of honors and Advanced Placement courses and the number of high school CTE courses students took. As another measure of students' engagement with school, we included absences and disciplinary incidences in 8^{th}-10^{th} grade.

To further minimize potential differences in motivation between participation and non-participating students, we did not restrict the treatment students to be compared only with nonparticipants from the same high school (i.e., we did not perform exact matching on high school or include school fixed effects in our primary models estimating impacts). This was because there could be systematic differences between a pathway student and his/her peers who attended the same high school, had similar demographic and academic characteristics, but did not choose to participate in a pathway in a given year. If not captured by the observable propensity scoring covariates, such differences may confound the effect of the pathways. The within-study comparison analyses we conducted with the experimental early college high school data (Unlu et al. 2021) suggests that imposing such geographical restrictions on QE comparison groups (also known as "local matching") may lead to biased effect estimates, which could be due to unforeseen imbalances on unobservable characteristics created by local matching. Nevertheless, we recognize that traditional analyses would use school-level fixed effects to account for unmeasurable differences between schools, so we also fit models with the school fixed effects. These results, in Appendix A, are nearly identical to the models without school fixed effects.

Given the rich set of school-level and individual-level covariates described above, we anticipate that our model captures most of the key factors associated with participation in the CTE dual enrollment pathway. While we cannot directly test the assumption of no (or minimal) selection bias in our model, evidence from a similar context – based on Early College High

Schools in North Carolina – indicates that the propensity score weighting approach we use can closely replicate experimental estimates when pre-treatment versions of the outcomes are included in the estimation of impacts (Unlu et al. 2021). While the outcomes we examine do not have natural pretests, we argue that our rich set of covariates should be good proxies for outcomes and selection into CTE. Furthermore, we conduct the Oster (2019) bounding exercise to examine the extent of which any confounders we do not have access to may bias our estimates (Appendix B). Overall, the qualitative findings are similar under a range of assumptions about selection bias in our estimates.

Sample

The sample analyzed for this paper was composed of seven cohorts of students, those who entered 11th grade in the 2012-2013 school year (with an anticipated graduation year of 2013-2014) through those enrolling in 11th grade in 2018-19 (with an anticipated graduation year of 2019-2020). Treatment students were students who were participating in the CTE dual enrollment pathway identified using the pathway participation indicator created by the Community College System. Prior to enrolling a student in a CCP course, colleges were required to identify the pathway (CTE, College Transfer or CIHS) for which the student was taking the course. For purposes of these analysis, a student was identified as being on the CTE pathway if they had a CTE pathway code at least once in 11th or 12th grade; this means that they could have taken as little as one CTE dual enrollment course. Students who were also enrolled in the College Transfer pathway in addition to the CTE pathway during their 11th or 12th grade years were still considered a treatment student. Students were identified in the 11th grade because that is the typical year in which non-CIHS students begin taking dual enrollment.[3] Students in both the treatment and comparison groups may have taken AP courses or university courses that were not part of CCP but the comparison group did not include students who participated in the other two CCP pathways (College Transfer and Cooperative Innovative High Schools). We excluded students from the other two pathways because—given the very different goals and target populations of the three pathways—it did not make sense to test the three pathways against each other.

Students can participate in the CTE dual enrollment pathway if they attend any high school in North Carolina, except for schools that are considered Cooperative Innovative High Schools (early college)[4], which were excluded from these samples. We also excluded a small number of small alternative high schools whose students lacked baseline exam score data.

The total sample included approximately 616,000 North Carolina students and the weighting procedure yielded tightly balanced treatment and comparison groups. Table 1 presents selected baseline characteristics[5] of the two samples of the students before and after weighting. As the table shows, all differences between the two groups once the weighting was incorporated were 0.04 standard deviations or smaller, which meets federal expectations for baseline equivalence (What Works Clearinghouse, 2022).

[3] Approximately 12% of all students enrolled in the CTE pathway are also enrolled in the College Transfer pathway and these students remain in the treatment group. We exclude from analyses a small number of students who participated in the CTE pathway in the ninth and/or tenth grade. This allows us to control for measures from ninth and tenth grade (e.g., GPA, advanced coursetaking, scores on high school exams) as covariates in the propensity weighting process, which increases the plausibility of the identifying assumption that we control for confounders of selection into the CTE pathway and outcomes.
[4] Note that students enrolled in a CIHS can take courses that fall under the CTE dual enrollment pathway, but their pathway designation would still be the CIHS pathway and not the CTE pathway.
[5] For brevity's sake, we did not include outcomes from additional waves of pretest data, nor did we present results from the school-level characteristics on which we weighted.

Table 1: *Baseline Characteristics of Treatment and Comparison Groups*

Variable	Treatment Mean	Unweighted Control Mean	Weighted Control Mean	Weighted Standardized Effect Size
Female	53.9%	47.4%	52.8%	0.021
White	62.0%	50.3%	61.5%	0.009
Black	18.9%	27.1%	19.2%	-0.007
Asian	1.2%	3.0%	1.3%	-0.008
Hispanic	12.1%	12.7%	12.0%	0.002
Native American	1.0%	1.1%	1.0%	0.002
Multiracial	4.7%	5.7%	4.9%	-0.008
Mobility	10.5%	16.1%	11.1%	-0.018
Age	16.3	16.4	16.3	-0.009
Gifted	15.6%	15.9%	15.2%	0.010
Disability status	6.3%	12.2%	6.6%	-0.015
Economic Disadvantage	41.7%	44.9%	42.4%	-0.016
ELL	1.7%	3.5%	1.8%	-0.008
Absences	6.92	7.78	7.03	-0.016
Ever Out of School Suspension	5.8%	8.9%	6.0%	-0.008
Ever In-School Suspension	8.7%	10.4%	9.0%	-0.011
8th grade math	0.07	0.01	0.06	0.016
8th grade reading	0.08	-0.01	0.07	0.017
Unweighted GPA	2.99	2.73	2.97	0.033
Honors courses	2.21	1.96	2.14	0.037
AP courses	0.09	0.15	0.09	0.007
High school CTE courses	1.58	1.22	1.58	-0.003

Data Sources and Outcomes

We linked data from the North Carolina Department of Public Instruction (including demographics, transcript data, attendance, suspensions, achievement data, high school graduation data), the University of North Carolina System (enrollment, transcript, and degree attainment data), and the North Carolina Community College System (enrollment, transcript, and degree/credential attainment data). As part of North Carolina's work on creating a State Longitudinal Data System, the three educational entities have created a Unique Identifier (UID) that allows for linking of individual students across sectors. We also had data on postsecondary enrollment from the National Student Clearinghouse for three of our cohorts of students.

We used these data to look at the following outcomes:

- *College credits earned by the end of 12th grade*. We examined the impact on the earning of both CTE college credits and on college credits that would be transferable to a four-year institution. Transferable credits could have been earned by passing college or university courses or by passing an Advanced Placement exam, defined as receiving a score of 3 or higher on the exam.
- *High school graduation.* This is defined as receiving a normal high school diploma within four years of entering high school.
- *Final high school GPA*, both weighted by the level of the courses and unweighted. This was either present in the data as the final GPA or, if not, was calculated based on students' cumulative GPA on the years in which they were included in the data.
- *Enrollment in a North Carolina public postsecondary institution* within one year after high school. This was defined in two ways. The first definition used data from the National Student Clearinghouse where we looked at enrollment in any two-year or four-

year institution for three of our cohorts. Because we did not have NSC data for all cohorts, we also examined enrollment using data from the North Carolina postsecondary systems. These data provided information around enrollment at either a North Carolina community college or a constituent member of the University of North Carolina System. We looked at the percentage of students who were enrolled in the year following 12th grade. For both sets of data, we assumed that students who were not present in the data were not enrolled. We report on findings using both of these data sources.

In this paper, we report analyses for three different subgroups:

- *Gender.* In the data, students were identified as either male or female.
- *Race/ethnicity*. In our analyses, we distinguished between racial and ethnic groups who were identified as underrepresented in college and those who were not. Underrepresented students included students who identified as Black or African-American, Native American, Hispanic/Latino and multiracial. Students who were not underrepresented were students who identified as White or Asian.
- *Economically disadvantaged.* Students who were identified as economically disadvantaged were coded as such in the system and received free or reduced-price lunch.

Analyses

As described above, because this was a statewide initiative rolled out at the same time, we had to use a quasi-experimental design that compared treatment participants with similar non-participants. Instead of doing matching, which would have required us to discard some data, we elected to use a propensity score weighting approach that allowed us to keep all students in the sample but gave additional weight to the outcomes of students who were most similar to the treatment group. The first stage in the weighting process was the estimation of propensity scores using generalized boosted modeling (GBM; McCaffrey et al. 2013). GBM combines boosting (i.e., iterations) and regression trees (which partition the dataset into numerous regions based on the covariate values). GBM is data adaptive and nonparametric; it automatically selects which covariates should be included and the best functional form by using many piecewise functions of the covariates and testing all possible interactions to achieve the best balance between the treatments and comparison units. We implemented GBM using a rich set of covariates including gender, race/ethnicity, age, gifted status, disability status, economically disadvantaged status, English Language Learner status, absences in baseline years, suspensions in baseline years, 8th grade reading and math scores, high school end-of-course exam scores taken prior to 11th grade, advanced courses taken prior to 11th grade, high school CTE courses taken prior to 11th grade, and an indicator for student mobility as well as the school-level covariates described above. We used the *Twang* package in Stata (Cefalu, Liu, and Martin 2015). As shown above in Table 1, the weighting was successful in creating a sample balanced on observable covariates.

The propensity score-based weights were used to weight the following prototypical model to estimate the impact of the CTE pathway:

(1) $Y_{ij} = \beta_0 + \beta_1 Trt_{ij} + \boldsymbol{X_{ij}\beta_2} + \boldsymbol{Z_j\beta_4} + \varepsilon_{ij}$

where Y_{ij} is the outcome for student *i* in school *j*; Trt_{ij} is participation status of student *i* in the CTE pathway; $\boldsymbol{X_{ij}}$ is the vector of student-level covariates listed above and cohort indicators[6]; $\boldsymbol{Z_j}$ is the vector of school-level covariates listed above; and ε_{ij} is the usual student-level residual. This model was estimated separately for each of the pathways we studied; in this case, for the CTE pathway and its corresponding comparison group and the corresponding propensity score

[6] For simplicity, we do not denote the cohort a student is in as a separate level. Cohort fixed effects are included as part of the student-level covariates since each student will be a member of a unique cohort.

weights. We clustered standard errors at the high school level (i.e., calculated cluster-robust standard errors) to take into account the clustering of students within schools. Another feature of the model is controlling for all variables that were used in the estimation of propensity scores as covariates, which is referred to as “doubly-robust modeling” (Bang and Robins 2005).

We probed heterogeneity in impact estimates using models that added an interaction between a student subgroup indicator (e.g., female students) and CTE participation. All analyses clustered standard errors at the high school level.

RESULTS AND DISCUSSION

Participation Rates

We begin with a descriptive analysis of participation in the CTE Dual Enrollment Pathway, looking at participation rates for students across the seven cohorts in our sample—those who started 11th grade in 2012-13 going through the cohorts that started 11th grade in 2018-19. We report the percentage of cohort students who took at least one dual enrollment course in the CTE pathway in 11th or 12th grade. To provide some context, we also include participation rates for the College Transfer Pathway, the other dual enrollment pathway implemented in comprehensive high schools. The participation rates for all students and for specific subgroups are shown as a percentage of the total enrollment of that population at comprehensive high schools in the state. As shown in Table 2, 9.3 percent of students in the seven cohorts of 11th graders in the analysis participated in the CTE Dual Enrollment Pathway. The participation rates by subgroup follow trends that represent the somewhat hybrid nature of CTE dual enrollment, with some trends more consistent with participation in CTE and some trends more consistent with participation in dual enrollment. For example, female students have higher than average representation in CTE dual enrollment courses; this is consistent with trends in dual enrollment where participation is higher by female students (Fink 2021; Xu, Solanki, and Fink 2021). It is also in contrast to gender trends in CTE enrollment where male students tend to earn more CTE credits than female students do (Carruthers et al. 2021).

Table 2: *Participation in CCP Pathways Offered at Comprehensive High Schools: College Transfer and CTE Dual Enrollment Pathways, Cohorts of 11th Graders From 2012-13 to 2018-19*

Characteristic	# Students	% in CTE Dual Enrollment Pathway	% in College Transfer Dual Enrollment Pathway
All Students	676,834	9.3%	10.1%
Black	168,661	7.1%	4.6%
Hispanic	82,307	9.3%	6.3%
White	361,757	10.8%	13.8%
Asian	18,946	4.1%	8.7%
Native American	7,628	8.5%	10.3%
Male	341,836	8.5%	7.2%
Female	334,819	10.2%	13.1%
ELL Students	19,832	5.2%	1.4%
AIG Students	117,374	8.2%	22.1%
Student with disabilities	69,226	5.6%	1.0%
Economically disadvantaged	276,534	9.3%	5.3%

How to read this table: Out of all Black students at comprehensive high schools in the seven cohorts of 11th graders in the analysis, 7.1 percent enrolled in the CTE dual enrollment pathway in 11th and/or 12th grade.

In looking at racial and ethnic groups, we see that there were some disparities in participation with White students most likely to participate in the CTE Dual Enrollment pathway and Asian students least likely to participate. Black students participated at a rate below the average, while Hispanic students participated at the same rate as the average for all students. The disparities within the CTE Dual Enrollment pathway, however, were much less stark than the disparities that existed in the College Transfer Pathway, where Black students participated at around a third of the rate of White students and Hispanic students participated at less than half the rate of White students. Existing research on dual enrollment indicates that students of color are much less likely to participate in dual enrollment courses than White students (Fink 2021; Xu et al. 2021). On the other hand, research on CTE participation presents mixed findings with some studies suggesting that there are no differences in participation among racial/ethnic groups (Dougherty 2016) and other studies indicating that White students are more likely to enroll in CTE and take more courses (Kim et al. 2021).

Economically disadvantaged students are much less likely to participate in dual enrollment courses than non-economically disadvantaged students (An and Taylor 2019; Pierson et al. 2017), a trend that we see in the College Transfer Pathway but not in the CTE pathway, where they were participating at the average rate. The participation rates for the CTE dual enrollment pathway were more consistent with the CTE research, which shows an unclear relationship between economic disadvantage and CTE participation. In some settings, economically disadvantaged students were more likely to participate in CTE (Reed et al. 2018); in other settings they were less likely to participate, although the differences were smaller than differences for gender (Carruthers et al. 2021).

Our findings thus suggest that there are disparities in participation between different subgroups in the CTE Dual Enrollment Pathway, although those disparities are not as extreme as those present in dual enrollment programs more broadly. We now move to examining how student outcomes are related to CTE pathway participation and the extent to which the results vary by certain populations.

Outcomes

Table 3 shows how core secondary outcomes are related to CTE pathway participation. CTE pathway participants earned an average of 5.8 college CTE credits compared to no credits for the comparison group; this outcome occurs essentially because of the definition of the intervention (i.e., the only way that students could have earned CTE college credits was through the CTE dual enrollment pathway). CTE Dual Enrollment Pathway students also earned an average of 4.8 transferable college credits compared to 1.5 credits for the comparison group; as a reminder, transferable credits could be earned both through dual enrollment and through passing AP exams. There were very small differences in the final weighted and unweighted high school GPAs across the groups. Weighted GPAs were significantly higher for CTE students while the differences for unweighted GPAs were not statistically significant.

Table 3: *Results of Participating in CTE Dual Enrollment Pathway, High School Outcomes*

Outcome	Treatment		Comparison		Impact Estimate (SE) -Preferred Model	Effect Size	Impact Estimate (SE)-School Fixed Effects
	Sample Size	Mean (SD)	Sample Size	Mean (SD)			
Total # of CTE college credits earned via CCP[a]	62,676	5.78 (6.14)	534,056	0 (0)	5.78*** (0.18)	2.9	5.81*** (0.18)
Total # of transferable credits earned	62,676	4.80 (8.47)	534,056	1.49 (5.50)	3.31*** (0.15)	0.56	3.17*** (0.14)
Final GPA (weighted)	62,546	3.24 (0.77)	528,076	3.23 (0.81)	0.011*** (0.002)	0.01	0.011*** (0.002)
Final GPA (unweighted)	62,543	2.97 (0.59)	528,026	2.96 (0.62)	0.003 (0.002)	<0.01	0.003* (0.002)
4-Year Graduation Rate	62,679	98.0% (13.4%)	534,477	96.0% (19.5%)	2.0 pp.*** (0.1)	-	2.1 pp.*** (0.1)

*$p \leq .05$; **$p \leq .01$; ***$p \leq .001$

How to read this table: CTE Pathway participants earned 5.78 CTE credits while the comparison students earned 0, an impact of 5.78, which was statistically significant. Notes: Comparison group means and standard deviations are weighted; effect sizes for continuous outcomes are calculated as the ratio of the impact estimate to the pooled (weighted) standard deviation.

Participants in the CTE pathway were statistically significantly more likely to graduate from high school than non-participants.[7] This finding is similar to the impact results for California's Concurrent Courses Initiative, which also found positive impacts on high school graduation rates for students participating in the initiative (Rodriguez et al., 2012). This is also consistent with research that has found positive impacts on high school graduation for CTE concentrators (Broderson et al. 2021) and with some of the limited research that has found positive impacts for dual enrollment on high school graduation (An and Taylor 2019), although it is inconsistent with a study of Washington State's dual enrollment program that found negative associations with high school graduation (Cowan and Goldhaber 2015).

Table 4 presents results on how pathway participation is related to the pathway on core postsecondary enrollment outcomes using both data from NSC and for only the NC public postsecondary institutions.

Table 4: *Impact of Participation in CTE Pathway, Postsecondary Enrollment*

Outcome	Treatment Mean (SD)	Comparison Mean (SD)	Impact Estimate (SE) –Preferred Model	Impact Estimate (SE)—School Fixed Effects
Enrollment outcomes using NSC data[a]				
Enrollment in any postsecondary school within one year	67.7% (47.1)	64.3% (47.9)	3.4 pp.*** (0.53)	3.8 pp.*** (0.55)

[7] Readers may wonder about the very high graduation rates in both groups. This occurs for two reasons. First, students in our sample were identified in 11th grade therefore any student who dropped out in 9th or 10th grade was not included in the sample. Second, students enrolling in dual enrollment likely have a relatively high interest in schooling overall and we would expect these types of students to be less likely to drop out.

Outcome	Treatment Mean (SD)	Comparison Mean (SD)	Impact Estimate (SE) –Preferred Model	Impact Estimate (SE)—School Fixed Effects
Enrollment in four-year institution within one year	31.4% (45.9)	34.8% (47.6)	-3.5 pp.*** (0.50)	-3.6 pp.*** (0.50)
Enrollment in two-year institution within one year	38.7% (48.7)	31.5% (46.4)	7.3%*** (0.55)	7.7%*** (0.57)
Enrollment outcomes using data from North Carolina Community College System and University of North Carolina System[b]				
Enrollment in NC public postsecondary school within one year	58.8% (49.1%)	48.8% (50.0%)	10.0 pp.*** (0.4%)	10.3 pp.*** (0.4%)
Enrollment in UNC System school within one year	21.5% (41.6%)	21.4% (41.0%)	0.2 pp. (0.3%)	0.2 pp. (0.3%)
Enrollment in NC community college within one year	39.5% (48.9%)	29.2% (45.4%)	10.4%*** (0.5%)	10.7%*** (0.5%)

*$p \leq .05$; **$p \leq .01$; ***$p \leq .001$
[a] Treatment sample size for NSC data: 20,916; comparison sample size: 235,334
[b] Treatment sample size for NC postsecondary institutions: 62,676; comparison sample size: 534,056
How to read this table: 58.8% of treatment students enrolled in any NC public postsecondary institution within the first year of leaving high school compared to 48.8% of comparison students. The impact was 10.0 percentage points and was statistically significant.

We look first at enrollment in any postsecondary institution using the NSC data, which we have for three of our seven cohorts. As shown in Table 4, we found positive, statistically significant relationships between participation and enrollments overall and at two-year institutions (specifically, a 7.3 percentage point impact on enrollment in two-year institutions, and a 3.4 percentage point impact on enrollment at any postsecondary school). For four-year enrollments, we found a negative, significant relationship of 3.5 percentage points in the NSC data. This suggests that the CCP CTE dual enrollment pathway may have been encouraging students to enroll in public institutions and may also have been shifting them from four-year to two-year institutions. It is important to keep in mind, however, that our outcomes captured postsecondary enrollment within one year of high school graduation and some of the CCP participants who were diverted from attending four-year colleges to two-year colleges may eventually enroll in four-year institutions after getting a technical credential or Associate degree and we plan to examine these longer-term outcomes in subsequent research.

It is possible that CCP may be encouraging students to enroll in NC public postsecondary institutions. Using the state data, we see a large and positive statistically significant relationship for enrollment in NC public postsecondary institutions overall, when including both UNC system schools and NC community colleges. Unlike with the NSC data, we see no significant relationship (negative or positive) on enrollment in a four-year UNC system school but there was a large and statistically significant 10.4 percentage point change in enrollment in a NC community college within one year. This is consistent with studies that show that dual enrollment students are more likely to enroll in postsecondary education with higher impacts for two-year institutions (An and Taylor 2019; Cowan and Goldhaber 2015). These results are larger than the ones from the study of the CCI Initiative, which found no impacts on overall enrollment but a small positive impact on four-year enrollment (Rodriguez et al. 2012).

Both Tables 3 and 4 present the impact estimates from the sensitivity analyses that we did using school fixed effects. As the table shows, the results are extremely similar to that of our preferred specification, which did not use school fixed effects. Full results for the school fixed effect analyses can be found in Appendix A.

Given the overall positive results for participation, the question then becomes whether results differ by specific subgroup. Given that we were subsetting these analyses for specific groups, we chose to use the largest sample possible and therefore report findings for NC public postsecondary enrollment instead of the NSC enrollment. When we look at results by subgroup (Table 5), we see that results were generally positive for most subgroups, except for enrollment in four-year colleges where results were negative for male students, non-underrepresented students, and non-economically disadvantaged students, suggesting that the model may have been moving certain populations of students away from four-year and into two-year enrollment.

Table 5: *Impact Estimates by Subgroup, Selected Outcomes*

Outcome	Gender		Underrepresented Race/Ethnicity		Economically-Disadvantaged	
	Male	Female	Underrep.	Not underrep.	EDS	Not EDS
Total # of CTE college credits earned via CCP	6.4***	5.2***	5.6***	5.9***	5.9***	5.7***
Differential impact	1.2***		-0.3*		0.2	
Total # of transferable credits earned	2.3***	4.2***	2.7***	3.7***	2.4***	4.0***
Differential impact	-1.9***		-1.0**		-1.5***	
4-Year Graduation Rate	2.0 pp***	2.0 pp***	2.0pp***	2.0pp***	2.9pp***	1.3pp***
Differential impact	0.1pp		0.0pp		1.6pp***	
Enrollment in NC public postsecondary school within one year	9.3pp***	10.6pp***	10.9pp***	9.4pp***	11.1pp***	9.1pp***
Differential impact	-1.3pp*		1.5pp*		2.0***	
Enrollment in UNC System school within one year	-0.9 pp*	1.1 pp**	1.5pp***	-0.6pp***	0.9pp**	-0.4pp
Differential impact	-2.1pp***		2.1pp***		1.3pp**	
Enrollment in NC community college within one year	10.5pp***	10.2pp***	9.9pp***	10.6pp***	10.6pp***	10.2pp***
Differential impact	0.2pp		-0.8pp		0.4pp	

*p≤.05; **p≤.01; ***p≤.001

How to read this table: The impact on the four-year graduation rate for males was 2.0 percentage points and for females, it was 2.0 percentage points. The impact was larger for males than females by 0.1 percentage point and this difference is not statistically significant.

Table 5 also shows the differences between subgroups and whether the differences between two subgroups was statistically significant; this is shown as the differential impact and is intended to indicate whether gaps between the two groups are growing or closing. For example, as the table shows, economically disadvantaged students experienced an increase in graduation rates that was statistically significantly larger than the results for not economically disadvantaged students (which was also positive but smaller).

Limitations

The study suffers from several limitations. The most critical is that we were unable to use an experimental design that would have allowed for us to ensure that treatment and control students were similar on unmeasured baseline characteristics such as interest and motivation. However, we did control for a rich variety of observable characteristics including measures that could be considered to represent academic motivation and potential interest in college (such as baseline measures of 9^{th} and 10^{th} grade honors, AP and high school CTE coursetaking). We also used the approach from Oster (2019) to estimate bounds for our main results under varied assumptions about selection bias on unobservable or unmeasurable characteristics. The bounds, presented in Appendix A, suggest that any remaining selection bias unaccounted for by observables is unlikely to substantially alter our main qualitative findings.[8]

A related limitation is that unmeasured factors unique to schools may be associated both with rates of participation in the CTE Dual Enrollment Pathway as well as with outcomes including postsecondary enrollments. Specifically, readers may have concerns that differences in

[8] The one exception to this is our findings related to high school graduation where the estimate becomes negative under the most extreme assumption of selection bias.

access to postsecondary institutions may simultaneously impact students' participation in dual enrollment and their attendance in postsecondary education. We have conducted descriptive analyses that suggest that the exact opposite situation exists in North Carolina. As might be expected, students in urban and suburban areas have postsecondary institutions that are closer to them than students in rural areas (mean of 4.3 miles vs. 7.1 miles). As might also be expected, students in urban/suburban areas also have higher postsecondary enrollment rates than students in rural areas/small towns (results from our NSC sample show that 62.8% of all cohort students in urban areas enrolled in some sort of postsecondary education by one year after high school compared to 58.5% of rural students). However, we also see that students in rural areas participate in CTE dual enrollment (or any dual enrollment) at a rate that is twice as high as students in urban areas (5% CTE dual enrollment participation in urban/suburban areas vs. 12% in rural/small towns). Therefore, we do not believe that this issue would upwardly bias our results; we do, however, find the urban/rural distinction in participation interesting and are exploring this issue in more depth in a separate paper. Although access to postsecondary institutions may not be influencing outcomes in the anticipated way, we did seek to statistically address the concern of other unmeasured school-level covariates by conducting a sensitivity analysis that included school fixed effects in our regression models. As noted earlier, we present the impact estimates in Tables 3 and 4 and the full results in Appendix A. They differ only negligibly from our preferred modeling approach that does not include school fixed effects.

An additional limitation is that we are missing NSC postsecondary enrollment data for the latter half of our cohorts. The state is expected to get access to these data over the next couple of years and we will replicate our main analyses with those additional populations of students.

CONCLUSIONS

As the first study of a statewide initiative, our study makes substantial contributions to a very limited and sparse literature base on CTE dual enrollment. Our study also contributes to a collection of studies in CTE and dual enrollment that have strong internal validity but whose findings are not necessarily applicable to the way in which CTE and dual enrollment are broadly implemented across the country.

Our results show that participating in the CTE dual enrollment pathway was positively associated with most outcomes in the full sample and for most of the subgroups we examined. CTE Dual Enrollment Pathway participants earned more college-level credits in high school, which can be considered an artifact of the intervention, although comparison students did have other options for college credit, including courses such as Advanced Placement. CTE Dual Enrollment Pathway students were also more likely to graduate from high school.

We also saw large positive relationships between CTE DE participation and enrollment in North Carolina community colleges ranging from 9.9 percentage points to 10.6 percentage points across subgroups. There is some evidence of substitution for certain subgroups of students where the model appeared to be redirecting some of the students who might otherwise go to a four-year to a two-year, which we see more vividly in the analyses using the NSC data. It is possible that this may not be a bad thing, however, if the courses helped a student recognize that they did not need to attend a four-year college for their desired career.

Overall, our findings show that it might be reasonable to expect participation rates and outcomes for CTE dual enrollment that represent its somewhat hybrid nature, combining CTE and dual enrollment. Participation patterns were more similar in some ways to dual enrollment and in others to CTE. The substantial difference in participation rates between the two types of dual enrollment pathways—college transfer and CTE—suggest that, moving forward, researchers should distinguish between CTE and college transfer dual enrollment when looking at participation and outcomes.

Our findings also suggest that CTE dual enrollment is a strong option for students. In many policy settings, CTE dual enrollment options are often considered as secondary to courses focused more on transfer to a four-year institution. Policymakers may want to ensure that policies exist to support CTE dual enrollment courses as well.

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Appendix A – Robustness Checks

This appendix contains robustness checks for the main results presented in the paper. First, we examine the sensitivity of our analyses to the inclusion of school fixed effects, which we do not include in our main models. By comparing pathway participants to non-participants at their same schools, we remove the effects of school-level variation in CTE participation and outcomes from the estimates, though we argue at the cost of exacerbating the potential for bias from unmeasured student-level differences between participants and non-participants. We find negligible differences between the school fixed effects models, presented in Table A.1 (high school outcomes) and Table A.2 (postsecondary outcomes), and our main results shown in Tables 5 and 6 of the main text. This suggests that the array of school-level covariates we do include in our models (e.g., locale, county economic tier, school size) account for the major ways that school-level differences affect outcomes.

Table A.1: *Impact of Participation in CTE Pathway, High School Outcomes, Sensitivity Analysis Including School Fixed Effects in Outcome Models*

Outcome	Treatment		Comparison		Impact	Effect
	Sample Size	Mean (SD)	Sample Size	Mean (SD)	Estimate (SE)	Size
Total # of CTE college credits earned via CCP	62,676	5.81 (6.14)	534,056	0 (0)	5.81*** (0.18)	2.9
Total # of transferable credits earned	62,676	4.65 (8.47)	534,056	1.49 (5.50)	3.17*** (0.14)	0.54
Final GPA (weighted)	62,546	3.24 (0.77)	528,076	3.23 (0.81)	0.011*** (0.002)	0.01

Outcome	Treatment		Comparison		Impact	Effect
	Sample Size	Mean (SD)	Sample Size	Mean (SD)	Estimate (SE)	Size
Final GPA (unweighted)	62,543	2.97 (0.59)	528,026	2.96 (0.62)	0.003* (0.002)	0.01
4-Year Graduation Rate	62,679	98.1% (13.4%)	534,477	96.0% (19.5%)	2.1 pp.*** (0.1)	-

*p≤.05; **p≤.01; ***p≤.001

Table A.2: *Impact of Participation in CTE Pathway, Postsecondary Enrollment, Sensitivity Analysis Including School Fixed Effects in Outcome Models*

Outcome	Treatment Mean (SD)	Comparison Mean (SD)	Impact Estimate (SE)
Enrollment outcomes using NSC data[a]			
Enrollment in any postsecondary school within one year	68.0% (47.1)	64.3% (47.9)	3.8 pp.*** (0.55)
Enrollment in four-year institution within one year	31.3% (45.9)	34.8% (47.6)	-3.6 pp.*** (0.50)
Enrollment in two-year institution within one year	39.2% (48.7)	31.5% (46.4)	7.7%*** (0.57)
Enrollment outcomes using data from North Carolina Community College System and University of North Carolina System[b]			
Enrollment in NC public postsecondary school within one year	59.1% (49.1%)	48.8% (50.0%)	10.3 pp.*** (0.4%)
Enrollment in UNC System school within one year	21.6% (41.6%)	21.4% (41.0%)	0.2 pp. (0.3%)
Enrollment in NC community college within one year	39.8% (48.9%)	29.2% (45.4%)	10.7%*** (0.5%)

*p≤.05; **p≤.01; ***p≤.001

[a] Treatment sample size for NSC data: 20,916; comparison sample size: 235,334

[b] Treatment sample size for NC postsecondary institutions: 62,676; comparison sample size: 534,056

Next, we use the approach from Oster (2019) to estimate bounds for our main estimates. This approach estimates selection on observables based on how much our estimates change when we add control variables to the models relative to the simple baseline model which regresses the outcomes on the treatment indicator. Based on varying assumptions about how much selection on unobservables compare to selection on observables we can obtain bounds for how our estimates may differ due to unobserved selection. Table A.3 shows the bounds under varying assumptions for the maximum R-squared in the columns with the header Beta. For most outcomes, the bounds are not substantially different from our main treatment estimate, indicating that any selection bias remaining in our estimates should not substantially change our qualitative findings. The columns with the header Delta indicate the value of delta for which the bias estimates are zero under the relevant maximum R-squared. This means they indicate how important the unobservables would need to be (relative to the observables) to produce a treatment effect of zero.

Note, these models compare outcomes in the models that include propensity score weights. The Oster (2019) approach is not suited for comparing models with propensity score weights to those without weighted since the weights change the R-squared. In our case the weights reduce the R-squared of the baseline model so we get a fully controlled model with a smaller R-squared than the simple OLS regression without weights. In this case, Oster's approach breaks down.

Table A.3. Estimates from Oster Bounding Approach

	Treatment Effect	R-max = 0.3		R-max = 0.5		R-max = 0.8		R-max = 1	
		Beta	Delta	Beta	Delta	Beta	Delta	Beta	Delta
Total # of CTE college credits earned via CCP	5.783			5.893	3.152	6.187	2.109	6.524	1.728
Total # of transferable credits earned	2.693			3.248	32.605	3.102	10.670	3.001	7.367
Final GPA (weighted)	0.011							0.008	3.673
Final GPA (unweighted)	0.003							0.000	0.989
4-Year Graduation Rate	0.020	0.015	3.679	0.011	1.918	0.003	1.116	-0.004	0.873
Enrollment in any postsecondary school within one year	0.113	0.040	-5.911	0.050	-2.050	0.064	-1.035	0.074	-0.779
Enrollment in four-year institution within one year	-0.035			-0.027	4.898	-0.017	1.947	-0.009	1.389
Enrollment in two-year institution within one year	0.073	0.070	-35.242	0.068	-19.313	0.065	-11.510	0.063	-9.067
Enrollment in NC public postsecondary within one year	0.100	0.089	7.089	0.075	3.331	0.053	1.856	0.036	1.433
Enrollment in UNC System school within one year	-0.046	0.000	0.837	-0.006	0.215	-0.016	0.102	-0.022	0.075
Enrollment in NC community college within one year	0.103	0.098	6.297	0.091	3.455	0.079	2.060	0.068	6.297

Notes: Some values are blank because the maximum R-squared used to compute the bounds (and amount of selection) is smaller than the R-squared in the original regression for the final GPA specifications with R-max of 0.8 or less so it is not possible to compute the bounds in these cases. The Beta columns indicate the upper (or lower) bound of the treatment effect based on the observed amount of selection on observables and the noted maximum R-squared, under the assumption that delta is one. The Delta columns indicate the value of delta for which the bias estimates are zero under a maximum R-squared of 0.3, 0.5, 0.8 or 1.0. For example, they indicate how important the unobservables would need to be (relative to the observables) to produce a treatment effect of zero.