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Abstract

We describe the postsecondary transitions of students taking CTE courses in high school using administrative data on one cohort of high school graduates in Washington State. Conditional on observable characteristics, CTE concentrators—high school graduates who complete at least four CTE credits—are about 4 percentage points less likely to enroll in college than other high school graduates. However, CTE students are significantly more likely to enroll in and complete vocational programs, especially in certificate programs in applied STEM and public safety fields. Among students not enrolled in college, CTE students are also more likely to obtain full-time employment—and to work more intensively—within the first three years following high school graduation. Although the improvements in employment outcomes do not offset reductions in college enrollment, the higher completion rates of vocational credentials among CTE concentrators indicate some important positive outcomes for this population.

1. Introduction

Under the Every Student Succeeds Act, nearly every state has included improvement in students' career readiness as a strategy in their state plans (Advance CTE, 2017). Career and technical education (CTE) coursework is perhaps the most common way students earn vocational skills during their secondary schooling. Nationally, more than 95% of students take at least one CTE course in high school, and low-achieving and special education students are even more likely to take a concentration of CTE courses (Theobald et al., 2019; U.S. Department of Education, Office of Planning, Evaluation and Policy Development, Policy and Program Studies Service, 2014). Despite the prominence of CTE coursework as a policy lever to improve career readiness, however, there is relatively little evidence about its relationship to key postsecondary outcomes.

In this study, we describe the high school completion rates and postsecondary transitions of students taking CTE courses in high school using administrative data on one cohort of high school students from Washington State. CTE concentrators—defined as high school graduates who complete at least four CTE credits during high school—are less likely to enroll in college than other high school graduates (65% versus 59% in our sample of high school graduates). But this may be somewhat related to the fact that students with a CTE concentration tend to be more disadvantaged—for instance, they are more likely to have learning disabilities, limited English proficiency, or to qualify for subsidized lunch programs—and hence less likely to enroll in college (Duncan, Kalil, & Ziol-Guest, 2018; Ziol-Guest & Lee, 2016).

Focusing only on enrollment may miss key ways in which high school CTE participation influences the postsecondary academic pursuits of college students. And decisions regarding the selection of college majors appear to be quite important. Holzer and Xu (2019) find that students enrolling in a range of certificate or occupational associate degree programs are more likely than other students to complete credentials; and several studies (e.g., Backes, Holzer, & Velez, 2015; Jepsen, Troske, & Coomes, 2014; Stevens et al., 2018) show that labor market returns to many (although not all) such programs are high, raising the earnings of these students above the earnings of students who finished only high school and those who completed terminal associate degrees in liberal arts.

Despite the importance of the career pathway chosen, however, there is relatively little evidence linking participation in secondary CTE to specific postsecondary career pathways. Using data that links high school CTE credits to postsecondary enrollment and pathways adds to the literature by investigating a census of high school students who take CTE courses in a variety of school and labor market contexts. In particular, we focus on the link between enrollment in high school CTE courses and continuation into specific vocational or academic programs in college. Following Holzer and Xu (2019), we classify postsecondary students based on their enrollment in traditional academic and vocational programs. These pathways include six routes to an associate degree for students enrolled in community colleges (liberal arts/social sciences; science, technology, engineering, and mathematics (STEM) programs; general occupational

programs; occupational business programs; occupational health programs; and applied STEM programs).

Our findings indicate that CTE students are less likely to enroll in college overall, which is largely explained by reductions in four-year college enrollment rates. But among students who do enroll in colleges, CTE students are significantly more likely to enroll in and complete vocational programs, especially in applied STEM and public safety fields. Among students not enrolled in college, CTE students also are more likely to obtain full-time employment—and to work more intensively—within the first three years following high school graduation. Thus, while the improvements in employment outcomes do not fully offset the reductions in four-year college enrollment we observe, the higher completion rates of vocational credentials among CTE concentrators who do enroll in college indicate some important positive outcomes for this population.

Our findings should be interpreted cautiously because we are not able to exploit any quasi-experimental evidence. In addition, we lack data on college enrollment outcomes for those studying in private or out-of-state colleges; and our data are limited to the state of Washington, where some minority groups that might benefit from vocational credentials—such as Black and Hispanic Americans—are underrepresented relative to the overall U.S. population. Nonetheless, our findings do indicate that the comparatively high rates of transition into postsecondary vocational programs among high school CTE students cannot be fully explained by differences in academic preparation or other observable student characteristics.

2. High School CTE Participation and Postsecondary Pursuits and the Washington State Context

Despite a significant body of literature describing links between high school CTE participation and postsecondary enrollment, the evidence regarding the *causal effects* of concentrating in CTE on general postsecondary enrollment is somewhat mixed. On the one hand, analyses of national and state longitudinal datasets suggest little relationship between CTE participation and college enrollment after controlling for baseline student characteristics and academic performance (Gottfried, Bozick, Rose, & Moore, 2016; Gottfried & Plasman, 2018; Jacobson & Mokher, 2014; Kreisman & Stange, 2018.

On the other hand, more structured CTE environments may serve to better improve student access to career opportunities. A number of studies have evaluated specialized high schools using data on admissions processes to control for student selection. Kemple and Willner (2008) studied career academies across the United States and found that students who received a randomized admissions offer earned higher incomes as adults, although they were no more likely to graduate from high school or to earn a postsecondary credential. Using data from the National Longitudinal Survey of Youth (1997 cohort), Kreisman and Stange (2018) found positive impacts of high school CTE courses on later earnings.

In addition, Hemelt, Lenard, and Paeplow (2019) studied career academies in Wake County Public Schools and found positive effects of CTE courses across a host of outcomes, including high school completion and college enrollment. Similarly, Neild, Boccanfuso, and Byrnes (2013) found positive effects of specialized CTE schools on high school completion and college preparation in Philadelphia. Dougherty (2018) estimated the effect of attending a specialized CTE high school in Massachusetts. Using a combination of selection on observables and regression discontinuity designs based on admissions data, he found that enrolling in a specialized school increased high school graduation and academic achievement.

There is significantly less evidence about how secondary CTE supports transitions into particular career pathways. Overall, about 10% of CTE concentrators (and about 14% of CTE concentrators who enroll in postsecondary education) entered a field of study related to their CTE concentration within two years of high school graduation (U.S. Department of Education, 2014). But these enrollment patterns, too, vary by field. Among students who enroll in college, in-field enrollment rates are highest for those with a health sciences (23%) or business (21%) CTE concentration, but these rates are much lower in other fields. However, whether these differences reflect causal relationships is unclear, particularly because the characteristics of students and job market opportunities for high school graduates differ significantly across fields. For instance, Jepsen et al. (2014) found that the labor market returns to health credentials earned in community colleges were relatively large compared with other career clusters. Thus, the observed differences in college enrollment may reflect differences in the value of credentials across fields rather than the effects of high school programs.

A few studies have linked secondary CTE data to students' career pathways in order to test whether participation causes students to select into vocational pathways after high school. Both Dougherty (2018) and Hemelt et al. (2019) found that students were more likely to earn industry credentials when they attended specialized CTE high schools. In one of the few studies linking secondary CTE to postsecondary educational pathways, Plasman, Gottfried, and Sublett (2017) used data from the ELS:2002 to follow students taking CTE courses in high school into and through college. They linked high school coursetaking to college completion outcomes and found that students who took more credits in a particular CTE concentration in high school were generally more likely to complete a postsecondary degree in that area. On the other hand, Gottfried et al. (2016) used data from the NLSY97 and found little evidence that CTE participation encouraged STEM majors for either general education students or those with learning disabilities.

We complement these studies with an analysis of the postsecondary pathways of CTE concentrators in Washington State. Students in Washington participate in CTE courses at rates similar to the national average. High school CTE in Washington is primarily offered through courses in comprehensive high schools, and courses are fairly evenly distributed across different career clusters (Theobald et al., 2019). In addition, Washington offers specialized dual credit and vocational programs that might improve students' access to specific postsecondary career

pathways. Running Start, the state's popular dual enrollment program, permits high school juniors and senior to take courses at public community colleges. About 10% of all high school students participate in Running Start, and 17% of participants take at least one vocational class (Washington State Board for Community and Technical Colleges, 2012).

Many schools also offer Tech Prep programs that provide vocational dual credit classes on the high school campus. There is some evidence that these programs may affect students' postsecondary plans. Cowan and Goldhaber (2015) found some evidence that participation in Running Start increased college enrollment at community colleges at the expense of enrollment in four-year colleges. In national data, Cellini (2006) found similar patterns for Tech Prep participants. In addition to these programs, Washington State offers a separate dual enrollment program specifically designed to prepare students for structured apprenticeships after high school (Washington State Apprenticeship and Training Council & Office of Superintendent of Public Instruction, 2008).

3. Data

In this study, we use data on recent high school graduates in Washington State. The data come from the statewide longitudinal data system at the Education Research and Data Center (ERDC). ERDC maintains a database of linked records across the state public education and unemployment insurance systems. We study the postsecondary transitions of the high school graduating class of 2013 using postsecondary and unemployment insurance data through 2016. We therefore examine the association between CTE participation and key postsecondary outcomes for up to three years following graduation.

Student Data

The high school data includes information on student demographics, standardized test results, and course enrollments. We primarily use student data from before high school enrollment in order to avoid conditioning on student characteristics that are possibly influenced by participation in CTE programming. We obtained data on students' baseline characteristics using their eighth- and ninth-grade enrollment records. We use standardized test scores in mathematics and reading for eighth-grade students. We use standardized test scores only from eighth grade given that CTE participation in high school may affect later student test scores. We also identify students' participation in special programs in ninth grade (learning disability status, free or reduced-price lunch programs, English language learner status, migrant status, homelessness and foster care status, and participation in gifted and bilingual education programs). We also measure students' final cumulative high school GPAs. The final analytical sample includes 38,987 students whose eighth-grade achievement data can be linked to high school completion records.

Outcome Measures

We construct several postsecondary outcomes using records from the State Board for Community and Technical Colleges, the Public Centralized Higher Education Enrollment System that tracks enrollment in public four-year colleges, and unemployment insurance records from the Employment Security Division. We first measure students' full-time postsecondary enrollment based on the highest level of enrollment (two- or four-year college) within three years after graduation. We then use earnings data to define three employment outcomes. We first define students as working full-time if they worked 375 hours or more for at least one quarter. We also measure the number of quarters of full-time employment within the first three years of high school graduation. Finally, we combine enrollment and employment outcomes and identify students who neither enroll in college nor work full-time during this period.

In addition, we construct career pathways and measures using data on college major choice. Pathway measures are based on the major students chose during the first term of college. Given the timing of major selection, the program pathways are better defined for students entering vocational programs. The community college system requires students participating in a program to report a program at the time of enrollment, but students in liberal arts programs in two- and four-year colleges typically do not report a major during the first term. We classify programs into liberal arts/social sciences, STEM, general occupational, occupational business, occupational health, and applied STEM pathways.[1]

We then define similar measures for the attainment of degrees and short-term credentials in the same fields within three years of high school graduation. We classify degrees into the same categories as student major choices. The short-term credentials are typically certificates requiring the completion of no more than one year of study. Studying earnings dynamics of students in other states, Jepsen et al. (2014) and Xu and Trimble (2016) found some evidence that these certificates improve labor market outcomes through increased earnings or employment. The college degrees are mostly two-year associate degrees that facilitate transfer to state four-year colleges. We first estimate attainment models that combine certificates and associate degrees into a single completion outcome and then focus on the completion of two-year degrees.

Importantly, the postsecondary data is limited to students who enroll in public colleges and universities in Washington State. We lack data on enrollment in private nonprofit and for-profit colleges and public institutions in other states. Although we do not have comparable enrollment statistics for the high school class of 2013, the institutions included in the administrative data

[1] We define general career pathways using the first two digits of the Classification of Instructional Programs code assigned to the major by the college. In particular, we assign Classification of Instructional Programs (CIP) codes 1, 3, 4, 10, 11, 15, 28, 29, 31, 34, 41, 47, and 60 to applied STEM; 5, 16, 22, 23, 24, 30, 33, 35, 38, 39, 42, 45, 50, and 54 to liberal arts/social sciences; 9, 12, 13, 19, 25, 36, 37, 43, 44, 46, 48, and 49 to occupational; 51 to health; and 52 to business.

cover between 78% and 83% of postsecondary enrollments for students in earlier cohorts (Cowan & Goldhaber, 2015; Education Research and Data Center, 2010).[2]

CTE Concentration

We identify *CTE concentrators* as those students who complete at least four credits of CTE coursework in high school. In Washington State high schools, one credit corresponds to a typical yearlong course. This definition follows prior work by Theobald, Goldhaber, Gratz, and Holden (2018) and Wagner, Newman, and Javitz (2016) on the postsecondary experiences of CTE students. Nonetheless, the results are substantively similar if we use the number of CTE credits students earn in high school rather than the binary concentration measure.[3]

On average, high school graduates in 2013 took 3.8 CTE credits in high school.[4] About 43% of graduating students qualified as CTE concentrators under this definition (Table 1). Concentrators took an average of about six credits of CTE courses during high school, compared with about two credits among all other students. CTE concentrators tended to have slightly weaker academic credentials than nonconcentrators: their eighth-grade achievement test scores were about 0.25 to 0.30 standard deviations lower than nonconcentrators, and their cumulative high school GPAs were about 0.25 points lower. CTE concentrators also tended to come from less advantaged backgrounds. They were about 10 percentage points more likely to qualify for free or reduced-price lunch programs in ninth grade, about 2.5 percentage points more likely to have a learning disability, and about 4 percentage points more likely to be English language learners.

Consistent with the differences in baseline characteristics, students who concentrated in CTE were less likely to enroll in college overall and more likely to enroll in state two-year colleges. About 65% of nonconcentrators and about 59% of concentrators enrolled in any public college in Washington State within three years of high school graduation. About 29% of nonconcentrators and 20% of concentrators attended four-year colleges, while 35% and 39%, respectively, attended two-year colleges.

4. Methods

In this study, we describe the postsecondary transitions of students who concentrate in CTE while in high school. As noted above, CTE concentrators tended to have lower baseline achievement and were more likely to come from disadvantaged student groups. In order to make more meaningful comparisons between concentrators and nonconcentrators, we estimated

[2] About 5% enrolled in-state private colleges, while 17% enrolled in out-of-state public or private colleges.
[3] We show results using the count of CTE credits and an alternative threshold for CTE concentration in Appendix Table A.1. Results are qualitatively similar to the main findings.
[4] This is slightly higher than estimates from a similar time period by Theobald et al. (2019), who found that students without disabilities took about three CTE credits and students with disabilities took about 3.5 CTE credits during high school. However, their sample includes entering cohorts of ninth graders, while ours includes only high school graduates who can be linked to eighth-grade enrollment records.

regression models to compare CTE concentrators to observationally similar students. Our most basic model used eighth-grade covariates as controls:

$$Y_{ij} = CTE_i\delta + X_i\beta + \overline{Z}_j\theta + \epsilon_{ij} \quad (2)$$

In Eq. (2), Y_{ij} indicates an outcome for student i in school j, CTE_i indicates a CTE concentrator, X_i is the vector of control variables, and $\overline{Z}_j$ contains the means of X_i and CTE_i at the school level. The inclusion of school means permits some correlation between unobserved high school effects on students' postsecondary outcomes and their CTE offerings (Wooldridge, 2010). In a linear model, including school means of the control variables provides estimates of δ and β that are numerically equivalent to including school fixed effects in Eq. (2). This equivalence result does not carry over to nonlinear models, but it does weaken the identifying assumption and permits straightforward estimation of average marginal effects. We therefore estimate Eq. (2) as a set of binary logit models.[5] Nonetheless, we are reluctant to describe δ as an estimate of the causal effect of participation in CTE during high school given the likely selection of students into CTE programs on the basis of their desire to complete vocational coursework after high school. However, it is worth noting that Dougherty (2018) finds that plausibly causal estimates of the effects of attending a specialized CTE high school on high school completion outcomes using a regression discontinuity design with admissions data are similar to those estimated using a selection on observables design with a similar set of covariates.

Two additional limitations of the analysis should be noted. First, the college enrollment data excludes enrollment records for students enrolling in in-state private schools or out-of-state public schools. As described above, we expect that 17%–22% of graduating students in our sample are incorrectly coded as not attending college. Unlike in the case of classical measurement error in the dependent variable, this type of classification error biases estimates of the contrast in college enrollment rates between CTE concentrators and nonconcentrators (Hausman, Abrevaya, & Scott-Morton, 1998). Because it is quite rare for students to enroll in two-year colleges in other states (Cowan & Goldhaber, 2015, the biases should disproportionately affect the college enrollment and four-year college enrollment regressions. If the probability of misclassification conditional on actual college enrollment is similar for CTE concentrators and nonconcentrators, we would expect the resulting coefficients to be biased toward zero by about 20%. However, if CTE concentrators are disproportionately more likely to continue in structured pathways at public two-year colleges, the estimated effects on overall college enrollment are likely biased upward. We therefore focus many of the analyses on students who enroll in two-year colleges. We find little association between CTE concentration and two-year college enrollment overall, and these outcomes are likely to be accurately measured given the rarity of enrolling in two-year colleges outside Washington.

[5] Results are similar for models estimated by multinomial logits and by conditional logits (high school fixed effects). Results available upon request.

A second limitation is that we have information only on students' final cumulative grade point averages. The inclusion of students' GPAs is potentially problematic because it is likely endogenous to CTE participation. However, prior research has shown that GPA captures skills that differ from those captured by academic achievement tests (Jackson, 2018). Thus, if our interest is in the effect of CTE coursework on student outcomes, controlling for baseline GPA would likely reduce bias relative to models controlling for achievement alone. Since this is not feasible in the current setting, we include 12th-grade cumulative GPA. However, we note that if CTE coursework is graded on a more lenient scale than other courses, the use of cumulative GPA would likely bias downward estimates of the association between CTE participation and postsecondary outcomes. Nonetheless, as we show below, results are generally not sensitive to the inclusion of cumulative GPA.

5. Results

Baseline Findings

In Table 2, we show the association between CTE concentration and postsecondary enrollment outcomes. We find that CTE concentrators are less likely to enroll in college overall by about 3.7 percentage points (see Column 6, Panel A of Table 2).[6] The lower enrollment rate is mostly explained by lower enrollment in four-year colleges (see Column 2). Depending on the specification, we find either no relationship or a slightly positive relationship between CTE participation and enrollment in a two-year college (Columns 3 and 4).

On the other hand, CTE concentrators are more likely to be working full-time. Among all students, CTE concentrators are about one percentage point more likely than nonconcentrators to work full-time in at least one quarter in the three years following high school graduation (Columns 1 and 2 of Panel B). CTE concentrators also work full-time more frequently throughout the years immediately following high school graduation. In Columns 3 and 4, we show that concentrators work full-time for an average of 0.11 more quarters within the three-year window. This finding is consistent with evidence described by Kemple (2008), Kreisman and Stange (2017), and earlier work by Paul Ryan (2001) and others who have found positive impacts of high school CTE on earnings.

In Columns 5 and 6 of Table 2, Panel B, we combine the results on college enrollment and employment. Overall, CTE concentrators are about 3 percentage points less likely to *either* enroll in college *or* work full time after high school graduation. It is important to note, however, that we cannot measure either out-of-state employment or enrollment in either private or out-of-state colleges. Both categories are erroneously categorized as not employed in our data. It is difficult to sign the resulting biases without additional information on CTE enrollment and employment

[6] Given that results are relatively similar across specifications, we focus on the models with cumulative GPA for the remainder of this paper.

patterns. On the one hand, private and out-of-state enrollment is more common in four-year than two-year colleges (Cowan & Goldhaber, 2015, which would lead us to understate differences in the combined enrollment or employment outcome between concentrators and nonconcentrators. On the other hand, if workers are more likely to cross state lines for employment than are students for college, then we may overstate this difference in Columns 5 and 6.

In Table 3, we focus on the initial educational programs selected by CTE students. In Panel A, we estimate models using the full sample of students enrolling in in-state public colleges; in Panel B, we restrict the analysis to students enrolling in public two-year colleges. Given that results are mainly similar across specifications, and the two-year data are likely to be significantly more accurate given the higher proportion of two-year college students covered by the state administrative data, we focus on the results in Panel B.

Not surprisingly, high school CTE students are significantly more likely to enroll in vocational programs in community college, such as applied STEM (2.9 percentage points), general occupational programs (2.8 percentage points), occupational business (0.8 percentage points), and occupational health (1.6 percentage points). We do not observe statistically significant differences among the nonvocational programs (liberal arts, social sciences, and STEM) in the two-year college sample, but note that students typically do not report enrolling in these programs during the first term in either two-year or four-year colleges. Overall, it appears that CTE students are more likely to transition into vocational programs following high school. Although we do not observe the type of CTE courses that students took (in high school or college), our findings are generally consistent with those of Plasman, Gottfried, and Sublett (2017) using national longitudinal surveys.

The findings on initial program selection also are reflected in longer-run measures of educational attainment. In Table 4, we show results from the analysis of educational degrees and credentials using the sample of students enrolling in any college (Panel A) and two-year colleges (Panel B). Because we do not observe students long enough to observe on-time completion of a four-year college degree, and because CTE students are less likely to enroll in four-year colleges, we again focus on the results for students enrolling in two-year colleges.

The results shown in Table 4, Column 1 indicate that CTE students are about 5 percentage points less likely to earn a two-year associate degree. The credentials we consider in Columns 2–6 of Panels A and B include both two-year associate degrees and shorter-term certificates. CTE concentrators are about 4 percentage points less likely to earn degrees in liberal arts and social sciences (Column 3). In Washington State, most of these credentials are associate degrees that facilitate entry into four-year colleges through transfer agreements with public and private colleges in the state.

However, CTE concentrators are significantly more likely to earn credentials in applied STEM and general occupational fields, which appear to lead to higher earnings in other studies (like Backes, Stevens, and others above). We estimate that CTE concentrators are about 1.4

percentage points more likely to earn a credential in applied STEM fields and 0.7 percentage points more likely to earn a credential in business fields.

In Panel C, we restrict attention to two-year associate degrees. In large part, the results reflect the patterns we see for major choice and general credentials. That is, CTE concentrators are less likely to complete degrees in liberal arts or social sciences and are more likely to complete degrees in vocational fields. In addition, we see some evidence that credentials in some fields are concentrated among short-term certificates. Although CTE concentrators are more likely to earn any credentials in occupational fields, they are actually less likely to earn a two-year degree. Similarly, CTE students are only about 0.2 percentage points more likely to earn a two-year applied STEM degree despite the fact that they are about 1.4 percentage points more likely to earn any applied STEM credential.

In results not shown, we disaggregate the general fields into those associated with particular career pathways in order to better understand what kinds of fields CTE students are entering. We use the definition of career pathways developed by the National Research Center for Career and Technical Education and match students' earned credentials based on the Classification for Instructional Programs code assigned by the community college system (Kotamraju & Steuernagel, 2012). Because these career pathways are not strictly aligned with the two-digit CIP codes we use to classify programs in this analysis, we focus on clusters that enroll large numbers of students and that are mostly contained within the field types we consider.

These data indicate that, within the applied STEM fields, CTE students are disproportionately more likely to earn credentials in information technology (network systems, information support services, and interactive media pathways) and manufacturing (maintenance, installation, and repair pathways). Within the general vocational field, CTE students earn more credentials in fields aligned with law and public safety (correction services, security and protective services, and law enforcement services pathways). Although we do not have direct evidence on the returns to these credentials in Washington State, Xu and Trimble (2016) find some evidence that certificates associated with maintenance and repair clusters result in increased earnings.

Heterogeneity by Student Type and Labor Market

Finally, we consider the relationship between participation in CTE and college enrollment and major choice for different students and labor markets in Washington State. We construct five regional labor markets as combinations of metropolitan areas (Seattle, Spokane, North Washington, Western Washington, Eastern Washington) and assign students to regions based on the locations of their high schools.[7] The state community college system operates 34 colleges

[7] The regions were chosen to be geographically contiguous and to contain at least 2,000 students. They are: Seattle (Seattle-Tacoma-Bellevue Metropolitan Area), Spokane (Spokane-Spokane Falls Metropolitan Area), North Washington (Bellingham and Mount Vernon-Anacortes Metropolitan Areas), Western Washington (Bremerton-Silverdale, Longview, Olympia-Tumwater, and Portland, OR-Vancouver-Hillsboro Metropolitan Areas; Western Washington Nonmetropolitan Area), and Eastern Washington (Kennewick-Richland, Lewiston, ID, Walla Walla, Wenatchee, and Yakima Metropolitan Areas; Eastern Washington Nonmetropolitan Area).

throughout the state, including multiple campuses in each of the labor market regions. Washington State also has public four-year colleges in each of the regions with the exception of Spokane-Spokane Valley.

In Table 5, we present results for the college enrollment and employment outcomes. Results for high- and low-achieving students are shown in the first two rows. We define high-achieving students as those with average eighth-grade mathematics and reading test scores above the state median. High-achieving CTE students enroll in college at a rate that is more similar to non-CTE students than do low-achieving CTE students, but the basic pattern of results is similar for both groups. They are less likely to enroll in four-year colleges, enroll in two-year colleges at similar rates, and less likely to enroll in college overall. High-achieving CTE students are not less likely than high-achieving non-CTE students to either work or enroll in public colleges during the three years following graduation from high school.[8]

We next consider postsecondary outcomes for students identified as having a learning disability in ninth grade. The results for this group are somewhat different than for other students. Although we find that students with disabilities (SWDs) who concentrate in CTE are still less likely than non-CTE students to enroll in four-year colleges, they are about 4 percentage points more likely to enroll in two-year colleges. Overall, SWDs who concentrate in CTE enroll in college and find employment at rates that are similar to non-CTE students.

Finally, we examine differences in enrollment and employment by region. The statewide patterns are reflected in the regional findings: CTE students are about 3 percentage points to 4.5 percentage points less likely to enroll in four-year colleges and are not statistically significantly more or less likely to enroll in public two-year colleges. The magnitude of the college enrollment gap (8.7 percentage points) is somewhat larger in North Washington than in other regions of the state. Measurement error is one possible explanation for these differences, as the North Washington region houses one of the largest in-state public universities (Western Washington University), has no large private colleges, and is the most distant region from a domestic state border. Thus, the classification error for the college enrollment and employment outcomes may be lower for students graduating from high school in this region than in other regions of the state.

In Table 6, we replicate the results for college major for each of the student subgroups. As with the statewide results, CTE students are more likely to enroll in vocational programs regardless of their eighth-grade achievement level. Relative to non-CTE students, both achievement groups are about 3 percentage points more likely to enroll in applied STEM programs, 2 percentage points to 3 percentage points more likely to enroll in general occupational programs, and 1.5 percentage points more likely to enroll in health programs in two-year colleges.

In Row 3 of Table 6, we estimate differences in college major by CTE concentration for SWDs. Given the small number of SWDs enrolling in two-year colleges in our sample, the CTE

[8] An important caveat, however, is that the lack of private or out-of-state college enrollment data is more likely to affect higher achieving students.

contrasts are imprecisely estimated and generally null. The only statistically significant result is for general occupational programs, which includes culinary, security, construction, and manufacturing fields. SWDs who concentrate in CTE during high school are about 4 percentage points more likely to begin one of these programs. The confidence intervals for the remaining point estimates generally include the estimates for the full sample, so the college major choices of SWDs who concentrate in CTE may not differ appreciably from those in other subgroups.

6. Discussion

In this paper, we provide descriptive evidence about the transitions of Washington State CTE students from high school to postsecondary education and the workforce. Despite an increasing focus of these programs in preparing students for further vocational or technical education, there has been relatively little evidence about whether students are successfully making these transitions.

As in other studies, we find that high school CTE raises full-time employment and reduces enrollment in four-year colleges. But the results also suggest that CTE students frequently continue studies in vocational programs, primarily at community colleges. While our data do not permit an examination of completion of four-year degrees, CTE students are significantly more likely to complete postsecondary credentials in vocational programs at two-year colleges. Since other analyses (e.g., Holzer & Xu, 2019) indicate that such credentials can generate important labor market rewards for groups with generally low college completion rates—especially low-achieving men—the positive outcomes we observe in these fields for CTE concentrators might improve their labor market performance in important ways.

Although we cannot conclude that participation in CTE programs causally affects students' career choices, the findings indicate that CTE pathways are linked to relevant postsecondary vocational education programs. This is an important finding in its own right given that alignment between secondary and postsecondary CTE is an explicit goal of Washington State's vocational education programs. Moreover, positive impacts of CTE on enrollment in at least some of the pathways indicated also imply positive impacts on credential attainment, especially certificates, and on subsequent earnings as well.

One important unanswered question is whether structured secondary CTE programs are aligned with students' future career pathways. Because we do not observe the specific career clusters in which students specialized during high school, we cannot determine how well students' secondary CTE experiences match their postsecondary programs. Plasman et al. (2017) used national longitudinal survey data and found that CTE concentration was associated with enrollment in aligned fields during college. However, it is not clear that more structured programs, such as the various dual credit models used in Washington State high schools, help prepare students for entry into specific postsecondary vocational programs.

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Tables

Table 1. Summary Statistics

	Total	Non-CTE Concentrators	CTE Concentrators
Total CTE Credits	3.814	2.104	6.043
	(2.509)	(0.993)	(2.105)
Student Outcomes			
Enrollment	0.623	0.646	0.592
	(0.485)	(0.478)	(0.492)
Four-Year College Enrollment	0.252	0.293	0.199
	(0.434)	(0.455)	(0.399)
Two-Year College Enrollment	0.370	0.354	0.392
	(0.483)	(0.478)	(0.488)
Any Full-Time Employment	0.058	0.052	0.067
	(0.235)	(0.222)	(0.250)
Quarters of Full-Time Employment	0.548	0.473	0.645
	(1.405)	(1.266)	(1.563)
Never Employed nor Enrolled	0.319	0.302	0.341
	(0.466)	(0.459)	(0.474)
Associate Degree	0.075	0.084	0.062
	(0.263)	(0.277)	(0.241)
Any Postsecondary Credential	0.112	0.122	0.100
	(0.315)	(0.327)	(0.299)
Student Characteristics			
Reading Test Scores	0.229	0.338	0.0867
	(0.895)	(0.886)	(0.887)
Mathematics Test Scores	0.251	0.388	0.0733
	(0.926)	(0.934)	(0.884)
Free or Reduced-Price Lunch Program	0.303	0.258	0.362
	(0.460)	(0.437)	(0.481)
Learning Disability Status	0.0734	0.0622	0.0879
	(0.261)	(0.242)	(0.283)
English Language Learner Status	0.136	0.118	0.159
	(0.343)	(0.323)	(0.366)
Gifted Program	0.0300	0.0415	0.0151
	(0.171)	(0.199)	(0.122)
Migrant Status	0.0104	0.00834	0.0131

	(0.101)	(0.0909)	(0.114)
Bilingual Education Program	0.0236	0.0190	0.0296
	(0.152)	(0.137)	(0.169)
Male	0.489	0.466	0.519
	(0.500)	(0.499)	(0.500)
African American	0.0401	0.0379	0.0429
	(0.196)	(0.191)	(0.203)
American Indian	0.0117	0.0113	0.0123
	(0.108)	(0.106)	(0.110)
Asian	0.0930	0.106	0.0765
	(0.290)	(0.307)	(0.266)
Pacific Islander	0.00575	0.00530	0.00632
	(0.0756)	(0.0726)	(0.0793)
Hispanic	0.137	0.116	0.165
	(0.344)	(0.320)	(0.372)
Multi-Racial	0.0546	0.0526	0.0573
	(0.227)	(0.223)	(0.232)
White	0.657	0.671	0.639
	(0.475)	(0.470)	(0.480)
Cumulative GPA	2.993	3.097	2.857
	(0.664)	(0.652)	(0.655)
Observations	38,987	22,068	16,919

Table 2. CTE Concentration, Postsecondary Enrollment and Employment

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. College Enrollment Outcomes						
	Four-Year Enrollment		Two-Year Enrollment		Any Enrollment	
CTE Concentrator	-0.040***	-0.036***	0.009*	0.001	-0.032***	-0.037***
	(0.004)	(0.005)	(0.005)	(0.006)	(0.005)	(0.006)
N	38,987	38,987	38,987	38,987	38,987	38,987
Panel B. Employment Outcomes						
	Any Full-Time Employment		Quarters of Full-Time Employment		Never Employed nor Enrolled in College	
CTE Concentrator	0.008***	0.010***	0.105***	0.116***	0.025***	0.029***
	(0.002)	(0.003)	(0.015)	(0.017)	(0.005)	(0.005)
N	39,305	38,987	39,305	38,987	39,305	38,987
High School GPA		X		X		X

Notes: Average marginal effects from logit regressions of college enrollment outcomes on indicator for CTE concentrator, eighth-grade reading and mathematics test scores, ninth-grade free or reduced-price lunch eligibility, sex, race/ethnicity, learning disability status, English language learner status, bilingual status, and gifted and talented identification, and the school cohort means of all student variables (including CTE concentration). Estimates in Columns (3) and (4) of Panel B estimated by OLS with high school fixed effects. CTE concentrator denotes student took at least 4 CTE credits in high school. Enrollment is defined as the highest level of college enrollment within three years of high school graduation. Full-time employment is defined as working at least 375 hours in one or more quarters during the first three years of high school graduation. High school GPA indicates final cumulative high school grade point average. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3. CTE Concentration and Initial College Majors

	(1) Applied STEM	(2) Lib/SS	(3) Occupational	(4) Business	(5) Health
Panel A. Students Enrolling in Public Colleges					
CTE Concentrator	0.020***	-0.010***	0.018***	0.005**	0.012***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)
N	24,275	24,275	24,275	24,275	24,275
Panel B. Students Enrolling in Public Two-Year Colleges					
CTE Concentrator	0.029***	-0.003	0.028***	0.008**	0.016***
	(0.004)	(0.002)	(0.005)	(0.003)	(0.005)
N	14,440	14,440	14,440	14,440	14,440

Notes: Average marginal effects from logit regressions of college major outcomes on indicator for CTE concentrator, eighth-grade reading and mathematics test scores, ninth-grade free or reduced-price lunch eligibility, sex, race/ethnicity, learning disability status, English language learner status, bilingual status, gifted and talented identification, high school GPA, and the school cohort means of all student variables (including CTE concentration). Standard errors in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4. CTE Concentration and Postsecondary Credentials

	(1) AA	(2) Applied STEM	(3) Lib/SS	(4) Occupational	(5) Business	(6) Health
Panel A. Students Enrolling in Public Colleges						
CTE Concentrator	-0.021***	0.008***	-0.030***	0.003*	0.003*	-0.002
	(0.005)	(0.002)	(0.005)	(0.002)	(0.002)	(0.002)
N	24,275	24,275	24,149	24,275	24,275	24,275
Panel B. Students Enrolling in Two-Year Public Colleges						
CTE Concentrator	-0.047***	0.014***	-0.042***	0.007***	0.003	-0.005*
	(0.007)	(0.003)	(0.007)	(0.003)	(0.003)	(0.003)
N	14,440	14,440	14,135	14,440	14,440	14,440
Panel C. Associate Degrees Only (Two-Year Public College Students)						
CTE Concentrator		0.002**	-0.043***	-0.002**	0.000	-0.004***
		(0.001)	(0.006)	(0.001)	(0.002)	(0.001)
N	14,440	14,440	14,135	14,440	14,440	14,440

Notes: Average marginal effects from logit regressions of college attainment outcomes on indicator for CTE concentrator, eighth-grade reading and mathematics test scores, ninth-grade free or reduced-price lunch eligibility, sex, race/ethnicity, learning disability status, English language learner status, bilingual status, gifted and talented identification, high school GPA, and the school cohort means of all student variables (including CTE concentration). Standard errors in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5. College Enrollment Outcomes for Student Subsamples

Subsample:	(1) Four-Year	(2) Two-Year	(3) Any	(4) Never Employed, Never Enrolled	(5) *N*
High Achieving	-0.031***	0.001	-0.028***	0.005	19,490
	(0.008)	(0.008)	(0.008)	(0.003)	
Low Achieving	-0.037***	-0.003	-0.047***	0.015***	19,497
	(0.005)	(0.008)	(0.008)	(0.004)	
Learning Disabled Students	-0.024***	0.038*	0.009	-0.002	2,860
	(0.009)	(0.021)	(0.020)	(0.011)	
Seattle-Tacoma-Bellevue	-0.035***	0.003	-0.033***	0.010***	22,240
	(0.007)	(0.007)	(0.007)	(0.003)	
Spokane-Spokane Valley	-0.031**	0.020	-0.019	0.001	3,427
	(0.015)	(0.019)	(0.019)	(0.009)	
North Washington	-0.045**	-0.037	-0.087***	0.040***	2,214
	(0.019)	(0.024)	(0.023)	(0.015)	
Western Washington	-0.035***	-0.011	-0.045***	0.004	6,069
	(0.012)	(0.015)	(0.015)	(0.007)	
Eastern Washington	-0.038***	0.024	-0.028*	-0.001	5,037
	(0.012)	(0.015)	(0.015)	(0.009)	

Notes: Average marginal effects from logit regressions of college enrollment outcomes for indicated subsamples. Dependent variables include an indicator for CTE concentrator, eighth-grade reading and mathematics test scores, ninth-grade free or reduced-price lunch eligibility, sex, race/ethnicity, learning disability status, English language learner status, bilingual status, gifted and talented identification, high school GPA, and the school cohort means of all student variables (including CTE concentration). Enrollment outcomes defined as in Table 2. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6. Initial College Majors for Student Subsamples

	(1) Applied STEM	(2) Occupational	(3) Business	(4) Health	(5) *N*
High Achieving	0.031***	0.019***	0.005	0.013**	5,894
	(0.006)	(0.006)	(0.005)	(0.007)	
Low Achieving	0.027***	0.032***	0.010**	0.017***	8,535
	(0.006)	(0.007)	(0.004)	(0.006)	
Learning Disabled	0.011	0.043**	0.010	0.006	1,166
	(0.019)	(0.021)	(0.012)	(0.015)	
Seattle-Tacoma-Bellevue	0.020***	0.019***	0.007*	0.016***	8,021
	(0.005)	(0.006)	(0.005)	(0.006)	
Spokane-Spokane Valley	0.022	0.033	0.033**	-0.025	1,144
	(0.017)	(0.020)	(0.016)	(0.015)	
North Washington	0.065***	0.085***	0.004	0.055***	932
	(0.020)	(0.026)	(0.011)	(0.021)	
Western Washington	0.045***	0.046***	0.018**	0.023**	2,495
	(0.011)	(0.012)	(0.008)	(0.011)	
Eastern Washington	0.047***	0.014	-0.002	0.025	1,795
	(0.014)	(0.014)	(0.011)	(0.016)	

Notes: Average marginal effects from logit regressions of college major outcomes for indicated subsamples of students enrolling in two-year colleges. Dependent variables include an indicator for CTE concentrator, eighth-grade reading and mathematics test scores, ninth-grade free or reduced-price lunch eligibility, sex, race/ethnicity, learning disability status, English language learner status, bilingual status, gifted and talented identification, high school GPA, and the school cohort means of all student variables (including CTE concentration). College major outcomes defined as in Table 3. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table A.1. Postsecondary Outcomes for Alternative Definitions of CTE Dosage

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Enrollment and Employment Outcomes						
	4-Year College	2-Year College	Any College	FT Employ.	Quarters of FT Employ.	No Enroll, No Employ.
CTE Credits	-0.007***	0.000	-0.008***	0.002***	0.029***	0.006***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.004)	(0.001)
N	38,987	38,987	38,987	38,987	38,987	38,987
>= 6 CTE Credits	-0.039***	-0.000	-0.038***	0.014***	0.159***	0.026***
	(0.006)	(0.007)	(0.007)	(0.003)	(0.021)	(0.007)
N	38,987	38,987	38,987	38,987	38,987	38,987
Panel B. College Major Outcomes (Two-Year College Students)						
	Applied STEM	Lib/SS	Occupational	Business	Health	
CTE Credits	0.007***	-0.001	0.007***	0.001*	0.004***	
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	
N	14,440	14,440	14,440	14,440	14,440	
>= 6 CTE Credits	0.032***	-0.003	0.030***	0.010***	0.007	
	(0.005)	(0.003)	(0.005)	(0.004)	(0.006)	
N	14,440	14,440	14,440	14,440	14,440	
Panel C. College Attainment Outcomes (Two-Year College Students)						
	AA	Applied STEM	Lib/SS	Occupational	Business	Health
CTE Credits	-0.012***	0.003***	-0.011***	0.003***	0.000	-0.002**
	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
N	14,440	14,440	14,440	14,135	14,440	14,440
>= 6 CTE Credits	-0.042***	0.013***	-0.034***	0.009***	0.003	-0.005
	(0.009)	(0.003)	(0.009)	(0.003)	(0.003)	(0.004)
N	14,440	14,440	14,440	14,135	14,440	14,440

Notes: Average marginal effects from logit regressions of college enrollment outcomes on indicator for CTE concentrator, eighth-grade reading and mathematics test scores, ninth-grade free or reduced-price lunch eligibility, sex, race/ethnicity, learning disability status, English language learner status, bilingual status, and gifted and talented identification, and the school cohort means of all student variables (including CTE concentration). High school GPA indicates final cumulative high school grade point average. Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$