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The Effect of High School Career and Technology Education on Postsecondary Enrollment and Early Career Wages

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Executive Summary

This report estimates the effect of completing a sequence of Career and Technology Education (CTE) courses in high school on enrollment in postsecondary education, graduation within five years, and workforce wages in the sixth year. Previous literature finds mixed results of the effect of CTE education, with some literature finding positive effects on postsecondary enrollment and workforce wages, and others finding substitution between two- and four-year postsecondary institutions. This report uses data from the Maryland Longitudinal Data System for students who graduated from Maryland public high schools in the 2009-2010 and the 2010-2011 academic years. Two empirical methods are used. First, CTE program completing students are matched with similar non-completers using a propensity score matching method and the differences are examined. The second method uses an instrumental variables strategy based on the fact that some students are in high schools closer to CTE Centers that offer CTE programs. Both methods generally find that CTE completing students, on average, were more likely to enroll in and receive a degree from a two-year institution and were less likely to enroll in and receive a degree from a four-year institution. On average, CTE completers had larger wages than non-completers six years after high school graduation. Differences in the effects by Career Cluster were also examined.

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Introduction

Career and Technology Education (CTE) remains a topic of considerable policy-making interest as a way of providing specialized training to high school students and opening career pathways to students for whom four-year postsecondary education may not be an optimal choice, or by providing specialized instruction to prepare students for specific college programs. Current CTE programs are designed such that students can complete the programs in addition to university preparation coursework and have a definitive end goal, such as an industry-recognized credential or postsecondary pathway. The United States devotes substantial resources to the development of CTE, and the recent reauthorization of the Carl D. Perkins Career and Technical Education Act represents a substantial commitment of government resources to CTE programs. Understanding the effect that CTE programs may have on student outcomes after high school helps evaluate the efficacy of these types of policies and whether they are achieving their state aims.

This study uses data from the Maryland Longitudinal Data System (MLDS) to examine the effect of completing a CTE program of study by completing the full sequence of courses required while in high school on a student's later enrollment in postsecondary education, degree receipt, and workforce wages. In addition to estimating the average effect of completing a CTE program, this study additionally breaks down the effects by the Career Cluster, or the type of CTE program completed in order to understand differences between the effects of completing different types of programs. The study uses a propensity-score matching approach to compare CTE program completers with those that did not complete CTE programs after controlling for observable differences between the two types of students. A complementary instrumental variables strategy that used the distance between a student's high school and the nearest CTE center was also used to estimate the same effects using an alternate method.

Background

There has been substantial research on vocational and CTE programs, though much of the existing estimated effects on post-high school outcomes are mixed. Earlier research on vocational education found that students who take vocational courses receive higher earnings but are less likely to complete a college degree (Bishop and Mane, 2005; Meer, 2007). More recent evidence has found mixed results and evidence that outcomes can depend on the type of CTE coursework completed, as concluded by a 2014 product of the U.S. Department of Education (U.S. Department of Education, 2014). This report commissioned quasi-experimental studies in several U.S. cities to examine the effects of CTE coursework. For example, study results from San Diego (Betts et al., 2014) and Philadelphia (Furstenberg and Neumark, 2005) found positive effects of CTE on postsecondary enrollment or aspirations of enrollment, while the study in Florida found no effect on college going for CTE students (Jacobson and Mokher, 2014). More recently, Kreisman and Stange (2017) found positive effects of advanced CTE

coursework on earnings after high school. Kreisman and Stange also found that there is some substitution between four- and two-year college enrollment, though they did not find that this extends to college degrees.

A previous study by the MLDS Center Research Branch used a propensity score matching technique to examine the effect of completing a health-related CTE program on the probability of enrolling in postsecondary education, the probability of obtaining a degree, and the effects of Health CTE completion on early career workforce wages (Witzen, 2018).[1] This study found that completers were more likely to enroll in college immediately after high school, with some substitution from four-year to two-year enrollment that extends to degree receipt. Health CTE completion was also associated with a higher likelihood of completing a degree in a health-related major, being employed in a health-related field 6 years after high school, and higher workforce wages within 6 years after high school graduation.

Career and Technology Education in Maryland

The United States has long funded vocational education, and the most recent iteration of this is the Carl D. Perkins Career and Technical Education Act of 2006, the fourth reauthorization of such funding since 1984. The Perkins Act provides grant aid to state and local education agencies to fund CTE programs in high schools and community colleges. The most recent version of the Perkins Act requires funded programs to offer a sequence of non-duplicative classes that help prepare students to enter postsecondary education or obtain an appropriate industry credential.

In the State of Maryland, there are 148 programs of study for students to choose from, organized into 10 ``Career Clusters" or course groupings of related programs.[2] A wide variety of programs are offered, ranging from pre-engineering programs designed to prepare students for studying engineering at a four-year institution to programs like carpentry and automotive technician that prepare students for recognized industry credentials. Local school systems have the ability to select and offer the programs that they believe best serve their students. To comply with the Perkins Act, all new programs must be approved by state and local governing bodies and must prepare students for a postsecondary pathway or for an industry credential. Some programs include opportunities, internships, shadowing, or other work experience that give students a direct opportunity to learn about the potential career options available upon completing a CTE program.

CTE programs are typically four-course sequences that students complete in their later years of high school. Typically, students begin with a CTE course in 10th grade, or two courses in 11th grade, and complete the sequence in 12th grade with two courses that include a capstone course. More recent CTE programs are intended to be easily completed with normal college preparation coursework, something intended to avoid ``tracking" programs that have plagued previous iterations of vocational education in the United States. Over 50% of students who complete CTE programs in Maryland also complete the minimum entry requirements for the University System of Maryland.

[1] This report can be found at https://mldscenter.maryland.gov/ResearchReports.html.

[2] A list of Career Clusters can be found in the Appendix

In addition to variation in the types of programs offered, there is also variation in how students access the coursework. The courses for some programs are available at regular public high schools, while other courses are offered at a CTE Center, an institution designed by the school system to provide CTE education for certain programs to all the schools in a local school system. These programs often tend to be capital intensive programs, such as those that require specialized equipment or instruction. A business or marketing program may be provided at a student's high school, for example, but an automotive technician program might instead be offered at the CTE Center in a student's local school system. Some systems may instead have technical high schools, that provide a higher variety of CTE programs than standard high schools but also provide standard high school curricula. These schools often function as magnet high schools where students apply for entry but can also accept part-time students who commute to the school for a portion of the day. School systems typically provide transportation in the form of busing for students to attend CTE Centers, but the commute during the day may still provide a cost that reduces a student's likelihood of completing a program.

The Current Study

To estimate the effect of CTE completion on postsecondary and workforce outcomes in Maryland, this study used a propensity-score matching technique (PSM) (Rosenbaum and Rubin, 1983) to match CTE completers with similar students who did not complete a CTE program based on observable demographics, test scores, and local school system characteristics. The paired students were then used to estimate the effect of a CTE program on a variety of post-high school outcomes, including college enrollment in years 1 and 4 after high school graduation, degree completion at postsecondary institutions, and workforce wages six years after high school graduation. The study also examined the same outcomes using an instrumental variables strategy where the distance between a student’s high school and the nearest CTE Center was used as a proxy for the physical and psychological cost of completing a CTE program.

This study adds to the existing literature on the effect of CTE program completion on postsecondary and workforce outcomes. Previous literature has found mixed effects of CTE completion on postsecondary outcomes, indicating that providing additional estimates can contribute to the existing body of work. Additionally, the previous literature has found differential results by the type of CTE program completed. This study provides an additional estimate of the effect of CTE programs by the type of CTE program completed. Previous reviews of the CTE literature have called for more quasi-experimental evidence on the effect of CTE programs (Ahn, 2017), and the PSM and instrumental variables techniques used in this study obtain such estimates.

Research Question

This report responds to the Maryland Longitudinal Data System Center (MLDSC) Research Agenda Question*:*

What are the workforce outcomes for Maryland high school students who complete Career Technical Education coursework, who either enter the workforce directly or also obtain postsecondary education or training?

Method

Data and sample selection

The data used for this report are from the Maryland Longitudinal Data System (MLDS), which contains linked longitudinal data from multiple State agencies.[3] The Maryland State Department of Education (MSDE) provides data for public PreK-12 students and schools. The Maryland Higher Education Commission (MHEC) provides data for Maryland public and state-aided independent college students and colleges, and data from the National Student Clearinghouse provides data on college enrollment for students attending out of state postsecondary institutions.[4] The Department of Labor Licensing and Regulation (DLLR) provides Unemployment Insurance (UI) wage records. A wage record is present for all workers in jobs for which their employer must participate in filing quarterly UI records. The federal government (including the military), certain non-profit and religious organizations, and private contractors (self-employed individuals) do not participate in quarterly UI filing.

For this report, data were used from students who completed high school at Maryland public high schools in the 2009-2010 and 2010-2011 academic years, to ensure a follow up period of 6 academic years in which to view postsecondary enrollment and degree completion.[5] Workforce wages 6 academic years after graduation were only available for the 2009-2010 graduating cohort. The total number of high school completers in the overall sample is 81,898 students.

A further limitation was used for the main portion of the analyses. In Maryland, students could complete high school in one of four categories: fulfilling the University System of Maryland (USM) course requirements for entry into the USM system, completing high school by completing a Career and Technology Education program, completing both the CTE and USM course requirements, and "other completions." In this study, students are only able to be viewed as completing a career cluster upon graduation, and after having taken all of the required coursework to complete a CTE sequence of courses. As completing a CTE program can

[3] For more information on the sources and data elements included in the MLDS, see https://mldscenter.maryland.gov/.

[4] For more information on the National Student Clearinghouse, please visit www.studentclearinghouse.org

[5] This measure includes high school completers of all types and only excludes high school non-completers.

be a method by which students complete high school, focusing on students who graduate in this way does not generate a natural comparison group among students who complete high school. However, by focusing on students who complete the USM requirements and those who do so while also completing a CTE program, there is a natural comparison group. Therefore, when comparing students who complete CTE programs and those who do not, the comparison is only made between USM completers. Over 50% of the CTE program completers meet the USM requirements in addition to completing a CTE program. This limitation to USM completion limits the data to 72,314 students in total for the main analyses and excludes any students who took CTE courses but not enough to complete a sequence of courses.

Measures

CTE Completion. To estimate the effect of completing a CTE program in high school, an indicator for whether a student completed a CTE program was created from the student's high school completion record and the Career Cluster as defined by the Classification of Instructional Programs (CIP) code of the CTE program completed. The total number of high school completers in the analytic sample who completed a CTE program was 20,060.

Throughout the remainder of the report, ``non-completers" will be used to refer to those who complete the USM requirements but do not complete a CTE program, which may include students who have taken or completed the CTE coursework for other CTE programs. Students who completed a CTE program in addition to the USM requirements will be labeled as "completers". In the first part of the summary statistics, a comparison is made between these groups and those who finish high school by completing a CTE program only (without fulfilling the USM requirements) to put these students in context.

Outcomes. The main student outcomes of the study are enrollment in postsecondary education, degree receipt, and workforce wages. To analyze the first outcome, a history of postsecondary enrollment was constructed for each high school completer. An indicator for enrollment in postsecondary education was created if the student was enrolled in the fall semester of an academic year that was X years after high school graduation. The level of institution ("2-year" or "4-year") was also included. A similar indicator was created for graduation, which equals to 1 if a student receives a degree of a given type within 6 academic years after high school completion. Each of these measures include enrollment and degree completion at any institution. Students are linked to Maryland MHEC data and data from the National Student Clearinghouse, which contains enrollment and degree completion data on students at a U.S. institution of higher learning.[6]

Workforce data were used to create measures of wages within an academic year. To align with academic years, wage years were coded such that quarters roughly match the academic year, thus earnings in the 2015-2016 academic year are from quarter 3, 2015 through quarter 2, 2016. Any missing quarters were coded as zero for a student, meaning that the workforce wages measures is the sum of all observed wages (including zeros) for the academic

[6] MHEC did not collect data on Spring, Summer, or Winter enrollment until the 2013-2014 academic year. This study limits to Fall enrollment only.

year approximation.[7] This study focuses on workforce wages 6 years after high school graduation.

Independent variables used in both analyses. Demographic and high school test score variables were included to match CTE completers to non-completers, which includes students who did not complete a CTE program as well as those who completed other types of CTE programs. These included a student's race, gender, and ethnicity, as well as an indicator for whether a student received special education. A student's free and reduced price meal (FARMS) eligibility was also included as a measure of socioeconomic status. Several measures of academic ability were also included. Three of these variables were the student's highest score on the Maryland High School Assessment (HSA) tests in English, Algebra, and Biology. One limitation of the HSA data for earlier cohorts in the MLDS is that HSA records are not available for students who took the exam before the 2007-2008 year (the year that the MLDS data begin). However, an indicator for having completed an HSA test in English or Algebra provided some information, as higher achieving students are more likely to take the exams earlier in their high school career.

Several variables were used to control for the geographic distribution of students and factors that might be related to geographic location. Indicator variables for the school system of the student were included to control for average differences in the outcomes between local school systems. Also, the distance between the student's high school and the nearest 2-year and 4-year institutions were included as a measure in order to help control for different costs of college attendance of CTE completers and non-completers.

Additional variables at the high school level were used to control for possible high-school level differences in CTE completion, college enrollment, college completion and workforce wages. Using publicly available data from the Maryland State Department of Education Report Cards[8], the rate at which a school's students pass the Algebra HSA exams in 2011 was used to control for average differences in school performance. Using the MLDS data, a school's percentage of students who were FARMS eligible was also included. Again, using the MLDS data, the total number of CTE programs available (measured by the number of programs taken by students in the MLDS data) at a school was included to control for differences in the availability of CTE programs.

Instrumental variables. The second strategy used in this report used distance from a student's high school to the nearest CTE Center as a proxy for the cost (both physical and psychological) of completing a CTE program. In school systems that have CTE centers that function as facilities where students from other schools can attend part-time to complete CTE programs (16 CTE Centers in total), the distance between a student's high school and the CTE Center was constructed from the latitude and longitude of the two schools in the MLDS data. Two measures were created, the first is the driving time between a student's high school (measured in the tenth grade) and the nearest CTE center, constructed using Google Maps. The second is the distance "as the crow flies" (straight distance) in miles. The driving time

[7] The analyses section describes measures undertaken to address the question of missing wage data

[8] This data is publicly available at http://reportcard.msde.maryland.gov.

instrument is the preferred option, and the straight distance results are included in the Appendix.

Analyses

To limit the observable differences between CTE completers and non-completers, a propensity-score matching method was utilized. A logistic regression was used to estimate a student's probability of completing a CTE program based on the observable characteristics described in the previous section. A student's propensity score, or probability of completing a CTE program based on observable characteristics, was used to match CTE completers with non-completers. In addition to the individual characteristics of the students, indicators for the student's local school system (LSS) were also included because students in a LSS that offers more CTE programs would have a higher likelihood of completing a CTE program. A nearest-neighbor matching method was utilized with each CTE completer matched to one non-completer without replacement. The matched data result in a total matched sample of 19,952 students (9,976 CTE completers and 9,976 non-completers). After obtaining the matched sample, simple linear regressions were run by regressing the dependent variable on an indicator for completing the CTE program and the control variables used in estimating the propensity score. In the case of a binary dependent variable, this method is a Linear Probability Model.

The PSM method was also used for each individual career cluster. The completers in each cluster were separately matched to non-completers using the same matching strategy to estimate the effect for each career cluster. The matching was done without replacement within each career cluster matching, but with replacement across career clusters, meaning that the same control students could appear in multiple career clusters.

The second set of analyses used an instrumental variables approach. In some school systems, separate facilities, known as CTE Centers, were established within the district to serve the in-district public schools. These Centers offer CTE program coursework towards the same career clusters accepted statewide. These Centers often offer programs that require specialist equipment or training, such that it makes sense to centralize the resources of the local school system to offer coursework at the district level. Students completing a CTE program at a CTE Center in their district can attend their normal high school for a portion of the day and then take courses at the CTE Center for the second portion of the day. Schools within the district provide transportation to and from the CTE Center for this purpose.

In previous work, such as that of Card (1995) or Conneely and Uusitalo (1998), the distance between a student's home and the nearest college was used as a proxy for the cost of attending the college. The further a student is from a college, the more difficult it is likely going to be to commute. These papers use this distance to estimate the return to completing college. In a similar way, this paper used the distance between a student's high school (in tenth grade) and the nearest CTE center as an instrument. It is possible that students further away from CTE centers, even if transportation is provided will find it more difficult or less appealing to complete a CTE program[9]. Therefore, this report used this distance as something that increased

[9] Whether or not this is true is investigated in the findings section.

the cost of completing a CTE program, which may differ for students at different high schools. Students at some high schools may face a larger cost for completing CTE programs than students at high schools nearer to the CTE Center.

There are two necessary assumptions for the instrumental variables strategy to provide a valid estimate of the effect of CTE completion. The first is that distance is, in fact, related to whether a student completes a CTE program. This report shows evidence for this in the following Findings section. The second necessary assumption is that the distance between a student's high school and the nearest CTE Center is unrelated to the student's postsecondary enrollment, degree completion, or workforce wages except by making it more difficult to complete a CTE program. This assumption is fundamentally untestable, but the Findings section provides evidence that the CTE Center distance is not too closely related to several observable variables. A more substantive discussion of the limitations of the method can be found in the Discussion section of this report.

When estimating the effect on workforce wages, several steps are taken to address differences in likelihood of CTE completers and non-completers in having positive wage data. In the main analyses, the estimates are restricted to those for whom there are positive wages in the MLDS. To get an idea of how the differences in the rates of missing wage data affects the estimates, statistical bounds on the wages effects following the methods of Lee (2009) were used[10]. Additionally, a separate analysis in which missing wage data is imputed using a predictive mean matching process using the available demographic and test score information prior to completing analyses is featured in the Appendix.

Findings

Using the Propensity Score Matching Method: Summary Statistics of the Sample

This study first examined summary statistics of students who complete and do not complete CTE programs in Table 1. This table breaks down several demographic and test score characteristics by the type of completion, with the three types being "USM only", for students who did not complete a CTE program but fulfilled the USM requirements, "CTE and USM", for students who completed both, and "CTE Only", for those students who completed only a CTE program. Though students who belong to the first and last columns will be the only ones included in the analysis, it is helpful to see how they differ from students who graduate high school by only completing a CTE program.

In Table 1, No CTE and those who complete both are fairly similar in demographic and test score characteristics. Those who complete both are slightly more likely to be male (47 percent versus 46 percent), White (60 percent versus 57 percent), and Black (30 percent versus 28 percent), less likely to be Asian (4 percent versus 8 percent) or Hispanic (5 percent versus 7 percent). CTE and USM completers are more likely to be FARMS eligible (24 percent versus 21

[10] This method estimates the increased likelihood of a CTE completer to appear in the wages and trims the top and bottom of the distribution of CTE completer wages, respectively, to ask the question "what if the missing *X* percentile of the distribution were the highest earners.

percent). The propensity to have an HSA Algebra test score and the score for those who do are similar between the two groups, but those who complete CTE programs have slightly lower HSA English scores. These students are also much more likely to have an available HSA Biology score, suggesting that students who complete CTE programs take Biology later in their high school career, on average. Students who complete CTE programs are generally the same distance from a college of any kind and are absent from school in nearly the same number of weeks. The same patterns exist for CTE only relative to USM only students, just with larger magnitudes in the differences. For example, 31% of CTE only students are FARMS eligible compared to 20% of USM only students. In general, we see that CTE students are more likely to be male, white, of low family income, and slightly less academically prepared.

At the school level, CTE completers are similar to non-completers, with 62 percent of students passing the Algebra HSA in schools attended by completers, compared to 61 percent in schools of non-completers. There is some evidence that schools of CTE completers offer more CTE programs (13 on average compared to 11) and have slightly higher rates of FARMS students (26 versus 23 percent).

Table 1. Summary Statistics of CTE and USM Completers

Variable	No CTE	CTE Only	CTE and USM
% Male	46	59	47
% White	57	64	60
% Black	28	29	30
% Asian	8	2	4
% Hispanic	7	4	5
% FARMS	21	33	24
% with HSA Algebra	29	69	33
Avg. HSA Algebra	429	421	431
% with HSA English	96	96	98
Avg. HSA English	426	402	419
% with HSA Biology	80	94	86
Avg. HSA Biology	435	414	431
Four-year Distance	10	13	11
Two-year Distance	7	10	7
Weeks Absent	2	3	2
School: HSA Algebra Pass Pct	61	66	62
School: # CTE Programs	11	15	13
School: FARMS %	23	24	26
N	61,838	9,584	10,476

Table 2 shows differences in raw (unadjusted for any covariates) outcomes, where rates of enrollment at the two types of postsecondary institutions, rates of degree receipt and annual wages 6 years after graduation are shown for the three types of students. Students who complete both are about 12 percentage points less likely to enroll in a four-year institution and 9 percentage points more likely to enroll in a two-year program immediately after high school

graduation. This difference is also apparent in the propensity to receive a degree, with those who complete both 11 percentage points less likely to receive a bachelor's degree and 5 percentage points more likely to obtain an associate's degree. Wages 6 years after high school graduation indicate that students who complete CTE programs have higher annual wages than those who complete only the USM requirements ($24,371 versus $22,055), and CTE completers are less likely to have missing wage data in the MLDS six years after high school graduation.

Table 2. Selected Raw Outcomes by Type of High School Completers

Variable	No CTE	CTE Only	CTE and USM
% Initial 2-year Enrollment	28	27	37
% Initial 4-year Enrollment	48	7	36
% Associate's degree earned	12	7	17
% Bachelor's degree earned	47	6	36
% With Positive Wages	31	36	35
Annual Wages 6 years later	22,055	21,353	24,371

To provide some idea of what CTE students study, Table 3 breaks down the type of program completed by each type of CTE completion (CTE and USM versus CTE Only), in order to give a percentage of completers who complete each type. Table 3 lists the Career Clusters on the left-hand side and the percentage of completers on the right. Several patterns emerge from this comparison. While students of each type of completion complete each type of program, students who complete both CTE and USM are much more likely to complete the Business, Management, and Finance; Health and Biosciences, and Human Resource Services programs. CTE Only students, on the other hand, are much more likely to complete Career, Research, and Development; Construction and Development; and Consumer Services, Hospitality, and Tourism programs. The types of programs completed, as well as the general summary statistics suggest that students who complete CTE and USM are different from students who complete CTE only. However, since more than 50% of CTE completers complete both a CTE program and the USM requirements, the CTE and USM completers remain a highly relevant subset of students.

Table 3. Program Types, CTE Only versus CTE and USM Completion

Program (% Completing)	CTE Only	CTE and USM
Arts, Media, and Communication	3	6
Business, Management, and Finance	10	18
Career Research and Development	21	6
Construction and Development	14	8
Consumer Services, Hospitality, and Tourism	13	10
Environmental, Agricultural, and Natural Resources	4	3
Health and Biosciences	4	12
Human Resource Services	14	17
Information Technology	3	7
Manufacturing, Engineering, and Technology	3	8
Transportation Technologies	9	4

Balance of the Propensity Score Matching Process

To match students via a propensity score a logistic regression was used to estimate the probability of completing a CTE program. To examine the balance, Table A.2 shows the standardized mean difference of demographic characteristics before and after matching. The standardized mean difference has an interpretation of Cohen's d, and magnitudes greater than .2 are generally considered large. As discussed in the prior subsection, the differences between the CTE and non-CTE students are not exceedingly large prior to the matching, with hardly any of the mean differences greater than .1. However, a χ^2 test of joint significance (including the county dummies not included in the table) show that we can still reject the null hypothesis that the means of CTE students are different from non-CTE students. After matching, the standardized mean differences of the matched sample are even smaller, and the χ^2 test does not reject the equivalence of the group means.

Effect of CTE Completion on Enrollment, Degrees, and Workforce Wages

In Tables 4 and 5, the matched sample is used to estimate the effects of CTE on enrollment at each type of institution for the four years following high school graduation. Table 4 shows the enrollment outcomes in years 1 and 2 after high school graduation, while Table 5 shows the effects for years 3 and 4 after high school graduation. Each column of Tables 4 and 5 corresponds to enrollment in that type of schooling for *X* years after high school graduation. The common pattern that emerges is a substitution towards 2-year enrollment from 4-year enrollment. CTE completion is associated with a 4.2 percentage point increase in the probability of attending a 2-year institution the year after high school graduation, and a 4.9 percentage point decrease in the probability of attending a four-year institution in the same year. This

pattern continues through years two and three, with a 3.0 percentage point increase in the probability of attending a two-year institution and a 5.4 percentage point decrease in attending a four-year in year 2, and a 2.6 percentage point increase in two-year enrollment in year three compared to a 6.1 percentage point decrease in four-year enrollment in year 3. By year 4, there is positive effect on two-year enrollment of 1.7 percentage points, and a 5.8 percentage point decrease in the probability of attending a four-year institution.

Table 4. Effects of CTE Completion on Enrollment by Type of Enrollment and Years After High School (1-2 years)

	Dependent variable:			
	2yr-1	4yr-1	2yr-2	4yr-2
	(1)	(2)	(3)	(4)
CTE completion	0.042***	-0.049***	0.030***	-0.054***
	(0.007)	(0.006)	(0.006)	(0.006)
Dep. mean	0.34	0.39	0.31	0.37
Observations	19,952	19,952	19,952	19,952

Note: * p<.1, ** p<.05, ***p<.01

Table 5. Effects of CTE Completion on Enrollment by Type of Enrollment and Years After High School (3-4) years

	Dependent variable:			
	2yr-3	4yr-3	2yr-4	4yr-4
	(1)	(2)	(3)	(4)
CTE completion	0.026***	-0.061***	0.017***	-0.058***
	(0.006)	(0.006)	(0.005)	(0.006)
Dep. mean	0.22	0.39	0.15	0.42
Observations	19,952	19,952	19,952	19,952

Note: * p<.1, ** p<.05, ***p<.01

Table 6 shows that this pattern extends to the degrees earned by each student within 6 academic years of high school graduation. The same substitution between the two-year and four-year enrollment appears to be present in degree completion. The effect of CTE completion on degree and certificate earning is shown in the columns, which display the effect on associate's, bachelor's, and certificate completion in columns (1), (2), and (3), respectively. Within 6 years after high school graduation, CTE completion is associated with a significant (p<.01) 3.6 percentage point increase in the probability of completing an associate's degree and a negative 4.8 percentage point effect (p<.01) for completing a Bachelor's degree. There is also a .5 percentage point increase in the likelihood of obtaining a certificate. Overall there appears to be a shift in enrollment between four-year and two-year programs for CTE completers, which extends to degree completion in Table 6.

Table 6. Effects of CTE Completion on Degree completion

	Dependent variable:		
	Associate's	Bachelors	Certificate
	(1)	(2)	(3)
CTE Completion	0.036***	-0.048***	0.005*
	(0.005)	(0.006)	(0.003)
Observations	19,952	19,952	19,952

Table 7 shows the effect of CTE on two measures of workforce wages. The first is the annual wages of a student in the sixth year after high school graduation (column (1)). The second (Column (2)) is the wages in the first year of any employment when a student is no longer enrolled in any education. CTE completion appears to be significantly (p<.01) associated with a $2,102 increase in annual wages in the sixth year after high school graduation. The effect on the annual wages in the first year of any employment is $1,565, which is also a statistically significant effect (p<.01). The combination of these results suggests that CTE completion is associated with higher workforce wages. The difference in the two effects also suggests that CTE completers, by the sixth year after high school graduation are also seeing benefits to experience, or time spent, in the workforce. The Lee (2009) bounds, included in the footer of the table, show that the estimated lower bound includes negative numbers, suggesting that it cannot be ruled out that the positive effect on wages is not due to the missing values. In the Appendix analysis table, smaller, but positive statistically, significant effects on wages were also found.

Table 7. The Effect of CTE Completion on Annual Workforce Wages

	Dependent variable: 6 years after high school	First Employment
	(1)	(2)
CTE Completion	2,102***	1,565***
	(413)	(359)
Lee Bound of the Effect Size (lower bound, upper bound)	(-611, 3581)	(-969, 2784)
Observations	7,082	7,082

Effect of CTE Completion on Enrollment, Degrees, and Workforce Wages, Examined by Career Cluster Completed

Tables 8 and 9 show the effect of CTE completion on enrollment and degree attainment, respectively, after the completion is broken down into the type of career cluster completed. These tables correspond to Tables 4 and 5 in their column labeling and the effects shown. The effects of CTE completion appear to be quite different by career cluster. Some clusters appear to be associated with general decreases in the probability of enrolling in a four-year program. Using the enrollment in the first year after high school graduation (Columns (1) and (2)), clusters such as "Arts, Media, and Communication", "Career Research and Development", "Health and Biosciences", "Human Resource Services", and "Transportation Technologies" appear to be associated with substantial substitution effects from a four-year program towards a two-year program. Other clusters, such as, "Construction and Development", "Environmental, Agricultural and Natural Resources" and "Consumer Services, Hospitality and Tourism" have negative effects on four-year enrollment, without as much substitution towards two-year enrollment. "Information Technology" appears to have a positive relationship with two-year enrollment.

Table 9 shows the effects of CTE completion on degrees earned within 6 years of high school graduation in a format analogous to that of Table 8. Several clusters are negatively associated with any bachelor's degree completion, such as "Career Research and Development", "Construction and Development", and "Transportation Technologies". Others show a substitution pattern from four-year degrees to two-year degrees, such as "Consumer Services, Hospitality, and Tourism", "Environmental, Agricultural, and Natural Resources", and "Health and Biosciences". "Human Resource Services" and "Information Technology" have positive effects on two-year degree completion. The only influence on earning a certificate is "Information Technology". "Business Management and Finance" is associated with a positive effect on Bachelor's degree receipt. In some cases, the degree effects are different than that of the enrollment effects. This could be true if CTE programs do not affect some students' enrollment patterns but change the likelihood of a student completing the degree for which they initially enrolled.

Lastly, Table 10 shows the effects of CTE completion by career cluster completed on workforce wages. Column (1) shows the effect on wages in the sixth year after high school completion, while Column (2) shows the effect on annual wages in the first year of any employment (not enrolled in any education). In general, CTE completion appears to have positive effects on wages in both measures. Some programs do not have significant effects on wages, such as "Arts, Media, and Communication", "Consumer Services, Hospitality and Tourism", "Human Resource Services" and "Environmental, Agricultural, and Natural Resources". The same patterns appear in the measure of wages at first employment. The overall average effect is slightly lower. The high wage programs, such as "Construction and Development" and "Transportation Technologies" in column (1) have effects smaller than the average effect over all of the clusters in Column (2). This may be evidence of how quickly experience converts into increased wages for students who complete these clusters.

Table 8. Enrollment Effects by CTE Cluster Completed

	Dependent variable:			
	2yr-1	4yr-1	2yr-4	4yr-4
	(1)	(2)	(3)	(4)
A. Arts, Media, and Communication	0.068***	-0.039	-0.003	-0.064***
	(0.026)	(0.024)	(0.019)	(0.024)
Observations	1,246	1,246	1,246	1,246
B. Business Management and Finance	0.029**	0.003	-0.021*	0.045***
	(0.015)	(0.014)	(0.011)	(0.014)
Observations	3,980	3,980	3,980	3,980
C. Career Research and Development	0.072***	-0.135***	0.038*	-0.163***
	(0.027)	(0.022)	(0.023)	(0.023)
Observations	1,204	1,204	1,204	1,204
D. Construction and Development	-0.037	-0.041**	0.016	-0.096***
	(0.024)	(0.021)	(0.017)	(0.021)
Observations	1,564	1,564	1,564	1,564
E. Consumer Services, Hospitality and Tourism	-0.010	-0.075***	0.002	-0.103***
	(0.020)	(0.018)	(0.015)	(0.019)
Observations	2,240	2,240	2,240	2,240
F. Environmental, Agricultural and Natural Resources	0.052	-0.124***	-0.021	-0.081**
	(0.037)	(0.034)	(0.030)	(0.035)
Observations	658	658	658	658
G. Health and Biosciences	0.097***	-0.025	0.086***	-0.059***
	(0.018)	(0.018)	(0.015)	(0.018)
Observations	2,502	2,502	2,502	2,502
I. Human Resource Services	0.035**	-0.028*	-0.003	-0.036**
	(0.016)	(0.014)	(0.012)	(0.014)
Observations	3,604	3,604	3,604	3,604
J. Information Technology	0.036	-0.005	0.016	0.017
	(0.023)	(0.023)	(0.017)	(0.023)
Observations	1,502	1,502	1,502	1,502
K. Manufacturing, Engineering and Technology	0.019	-0.017	0.009	-0.025
	(0.022)	(0.022)	(0.016)	(0.022)
Observations	1,644	1,644	1,644	1,644
L. Transportation Technologies	-0.007	-0.151***	-0.068***	-0.143***
	(0.033)	(0.026)	(0.025)	(0.028)
Observations	872	872	872	872

Table 9. Degree Effects of CTE Completion by Cluster Completed

	Dependent variable:		
	Associate's	Bachelor's	Certificate
	(1)	(2)	(3)
A. Arts, Media, and Communication	0.007	-0.062***	0.011
	(0.019)	(0.024)	(0.010)
Observations	1,246	1,246	1,246
B. Business Management and Finance	0.007	0.038***	-0.002
	(0.011)	(0.013)	(0.006)
Observations	3,980	3,980	3,980
C. Career Research and Development	-0.005	-0.130***	-0.002
	(0.019)	(0.022)	(0.011)
Observations	1,204	1,204	1,204
D. Construction and Development	0.008	-0.069***	0.004
	(0.017)	(0.021)	(0.009)
Observations	1,564	1,564	1,564
E. Consumer Services, Hospitality and Tourism	0.068***	-0.092***	-0.007
	(0.016)	(0.018)	(0.007)
Observations	2,240	2,240	2,240
F. Environmental, Agricultural and Natural Resources	0.063**	-0.092***	-0.012
	(0.032)	(0.035)	(0.014)
Observations	658	658	658
G. Health and Biosciences	0.053***	-0.051***	0.001
	(0.015)	(0.017)	(0.008)
Observations	2,502	2,502	2,502
I. Human Resource Services	0.030**	-0.019	-0.008
	(0.012)	(0.014)	(0.006)
Observations	3,604	3,604	3,604
J. Information Technology	0.049***	-0.029	0.022**
	(0.018)	(0.023)	(0.010)
Observations	1,502	1,502	1,502
K. Manufacturing, Engineering and Technology	0.012	-0.038*	0.001
	(0.018)	(0.022)	(0.009)
Observations	1,644	1,644	1,644
L. Transportation Technologies	0.036	-0.144***	0.013
	(0.024)	(0.026)	(0.010)
Observations	872	872	872

Table 10. Workforce Wages Effects of CTE Completion by Cluster Completed

	Dependent variable: 6 years after high school	First Employment
	(1)	(2)
A. Arts, Media, and Communication	3	358
	(0.019)	(0.024)
Observations	367	367
B. Business Management and Finance	2,115**	2,353***
	(821)	(731)
Observations	1,661	1,661
C. Career Research and Development	3,311**	2,537**
	(1,440)	(1,170)
Observations	441	441
D. Construction and Development	3,046*	633
	(1,676)	(1,362)
Observations	520	520
E. Consumer Services, Hospitality and Tourism	465	-1,018
	(1,130)	(1,029)
Observations	719	719
F. Environmental, Agricultural and Natural Resources	-1,163	-2,933
	(2,192)	(1,831)
Observations	253	253
G. Health and Biosciences	1,037	1,383
	(1,190)	(1,085)
Observations	852	852
I. Human Resource Services	1,375	536
	(886)	(828)
Observations		
J. Information Technology	11	2,033
	(1,873)	(1,558)
Observations	538	538
K. Manufacturing, Engineering and Technology	-786	1,811
	(1,958)	(1,672)
Observations	490	490
L. Transportation Technologies	6,292***	-282
	(2,400)	(1,923)
Observations	298	298

Using the Instrumental Variables Method: Effects on First-year Enrollment, Degrees Received, and Workforce Wages Six Years After Graduation

Tables 11, 12 and 13 use the instrumental variables (IV) method to estimate the effect of completing a CTE program on college enrollment, degree receipt and workforce wages. In driving time, the average time to a CTE center in the districts with CTE Centers is 15 minutes. The 25th percentile of distance is 10 minutes, and the 75th percentile is 20 minutes. The distribution of the driving time distance measure is skewed towards the lower end of time, and therefore the natural logarithm of the driving time was used as the instrument. In the first row of each table, the estimate of the effect of log (driving time) on the outcome is presented. In the second row of each table, the IV estimate of the effect of CTE completion, using log (driving time) as the instrument is shown. Using the effect on attending a two-year institution as an example outcome, the first row of each table displays the effect of a 1% change in driving time on the probability of enrolling in a two-year institution. The second row estimates the effect of completing a CTE program on the probability of enrolling in a two-year institution. Versions of Tables 11, 12, and 13 that use log (straight distance) as the instrument can be found in the Appendix, with similar results.

Table 11 shows the reduced-form and instrumental variables estimates of the effect of completing a CTE program on initially enrolling in a two- or four-year institution after high school graduation. The first column shows that a 1% increase in driving distance makes a student 3.8 percentage points less likely to complete a CTE program. This association is quite large and very strong. The first row of Table 11 shows that a 1% increase in CTE Center driving distance is associated with a 0.8 percentage point reduction in two-year enrollment, and a 0.8 percentage point increase in four-year enrollment. The second row puts this effect in terms of the effect of completing a CTE program. There is a significant 21.7 percentage point increase in the likelihood of two-year enrollment with a 20.1 percentage point decrease in the likelihood of four-year enrollment.

Table 11. Instrumental Variable Estimation of the Effect on Enrollment One Year After High School

	Dependent variable:				
	CTE Completion	Two-year Enroll. (1 year later)		Four-year Enroll. (1 year later)	
	(1)	(2)	(3)	(4)	(5)
Log (driving time)	-0.038***	-0.008***		0.008**	
	(0.002)	(0.003)		(0.003)	
CTE Completion			0.217***		-0.201**
			(0.080)		(0.083)
Dep. Mean	0.129	0.284	0.284	0.513	0.513
Observations	29,885	29,885	29,885	29,885	29,885

As in the propensity score matching results, the IV results find similar switching from four-year to two-year in both the enrollment and the degree effects. The first row of Table 12 shows that a 1% increase in driving distance decreases the likelihood of an associate's degree by a non-statistically significant -.03 percentage points, increases the bachelor's degree receipt by 1 percentage point, and reduces the likelihood of receiving a certificate by .4 percentage

points. The bachelor's degree and certificate effects amount to a 27.8 percentage point decrease and 9.7 percentage point increase in receiving the two credentials, respectively. This degree effect suggests that CTE program completers attend two-year colleges to complete certificates as well as associate's degrees. This is consistent with programs such as Health and Biosciences, which contains nursing programs that have associated certificate programs at many community colleges.

Table 12. Instrumental Variable Estimation on Degree Receipt

	Dependent variable:						
	CTE Completion	Associate's		Bachelor's		Certificate	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log (driving time)	-0.038***	-0.003		0.010***		-0.004***	
	(0.002)	(0.002)		(0.003)		(0.001)	
CTE Completion			0.069		-0.278***		0.097***
			(0.063)		(0.082)		(0.031)
Dep. Mean	0.129	0.138	0.138	0.518	0.518	0.029	0.029
Observations	29,885	29,885	29,885	29,885	29,885	29,885	29,885

Lastly, the instrumental variables strategy examines the effect on workforce wages, both six years after graduation and at the time of first employment. A 1% increase in distance to a CTE center was associated with a significant $523 decrease in wages six years after graduation and a $419 decrease in wages at first employment. Scaled to the effect for completing a CTE program, these effect sizes are $15,724 and $12,591, respectively. These are quite large effects, but consistent with the propensity score analysis in finding positive effects on workforce wages.

Table 13. Instrumental Variable Estimation on Workforce Wages

	Dependent variable:				
	CTE Completion	Wages 6 Years Later		Wages at First Employment	
	(1)	(2)	(3)	(4)	(5)
Log (driving time)	-0.033***	-523**		-419**	
	(0.003)	(225)		(200)	
CTE Completion			15,724**		12,591**
			(6,963)		(6,168)
Dep. Mean	0.129	0.19	0.19	23242	18003
Observations	14,720	8,962	8,962	8,962	8,962

Summary of Findings

In this report, a propensity-score matching approach and an instrumental variable method was used to examine the effect of completing a Career and Technology education (CTE) program in high school on college enrollment, degree completion, and workforce wages six years after high school graduation. Overall CTE completion is associated with a shift from four-year postsecondary enrollment and degree completion to two-year enrollment and degree completion, using both methods. When examined by the type of career cluster completed, the effects on enrollment and degree completion can be very different by cluster, with some programs leading to substitution between two- and four-year programs, while others leading to lower likelihood of enrolling in college at all, and others having no effect. Overall CTE completion is associated with a $2,102 increase in workforce wages in the sixth year after high school graduation. Most clusters were associated with positive effects on workforce wages, suggesting that CTE programs might lead students to make different enrollment and degree decisions, but may still have positive effects on a student's wages, at least early in their career.

Discussion

The main effects of CTE point to substitution away from four-year degrees and towards two-year degrees, which is consistent with earlier work of Bishop and Mane (2005) and Meer (2007), who also find positive effects on wages. Kreisman and Stange (2017) also find a substitution effect on initial enrollment, though this does not materialize in degree receipt. Each of these papers also find positive effects on workforce wages, similar to those found in this study. The overall effect of CTE programs also is consistent with a previous report by Witzen (2018), who found similar effects among students who completed Health-related CTE programs, in that students were more likely to substitute from one degree type to the other, but found an overall positive effect on wages.

There are several important caveats to keep in mind when interpreting the results of this study, particularly if trying to establish a causal link between CTE and any of the outcomes explored in this study. The first caveat is that the propensity-score matching procedure accounts for *observable* differences between CTE completers and non-completers. If there are additional factors unobserved in this data that both cause a student to enroll in a CTE program and also affect a student's enrollment, degree-earning, or wages, then this would introduce bias into the estimate of the effect of CTE completion. One such example would be if there is some sort of specific technical skill (such as that observed by Urzua and Prada (2017)) that causes students to sort into CTE programs, but that also might separately influence their wages or enrollment decisions. The second is the limitation that the study only examines students who complete a high school degree and limits to students who complete the University System of Maryland requirements. This is necessary to have adequate comparisons when CTE completion is only observed at the time of high school completion, however, this leaves open the question as to what effects CTE might have on high school completion for those who only complete via a CTE program. Dougherty (2018) finds that high school CTE programs make students significantly

more likely to complete a high school degree, therefore, future research in Maryland could examine the effect of CTE programs on high school graduation.

Additionally, the instrumental variables approach also requires important caveats. One of the important assumptions for the instrumental variables approach to estimate the effect of completing a CTE program is for the distance between a student's high school and a CTE Center to be unrelated to the outcomes of study except through the completion of a CTE program. While demographic and school information, particularly distance from a two- and four-year postsecondary institution were controlled for, if the distance between a student's high school and the CTE center is otherwise related to their likelihood to attend college and work, then the method will produce biased estimates.

Conclusion

This report examined the effect of completing a Career and Technology Education (CTE) program on postsecondary enrollment, degree completion, and workforce outcomes. A propensity-score matching strategy was used to compare CTE program-completing students with non-completers while controlling for observable differences between the types of students. Additionally, an instrumental variable approach that compared students whose high schools were further from CTE Centers was used as a supplemental approach. The report found that CTE completing students, on average, were more likely to enroll in and receive a degree from a two-year degree granting institution and were less likely to enroll in and receive a degree from a four-year institution. On average, CTE completers had larger wages than non-completers six years after high school graduation. All of these effects were also examined by the Career Cluster of the program completed, and there was substantial variation in the effects by the Cluster completed, with some leading to the substitution behavior, some leading students to be less likely to enroll in college at all, and some having no significant effect. Most Career Clusters seemed to lead to students having higher workforce wages six years after high school graduation. These results suggest that CTE completion might affect the type of institution a student enrolls in and which degree they receive, however, generally CTE completion leads to larger wages early in a student's career.

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Appendix

Table A.1 List of Maryland Career and Technology Clusters[11]

Arts, Media, and Communications	Business Management and Finance	Construction and Development
Consumer Service, Hospitality, and Tourism	Environmental, Agricultural, and Natural Resources	Human Resource Services
Information Technology	Manufacturing, Engineering, and Technology	Transportation Technologies
Career Research and Development		

Table A.2 Standardized Mean Differences, Unmatched vs. Matched

Variable	Unmatched	Matched
Male	0.008	0.005
White	0.036	0.003
Black	0.063	0.005
Asian	0.142	0.006
Hispanic	0.055	0.004
FARMS	0.089	0.017
% HSA Algebra	0.089	0.006
HSA Algebra	0.084	0.008
% HSA English	0.054	0
HSA English	0.035	0.002
% HSA Biology	0.083	0.008
HSA Biology	0.071	0.01
Special Ed.	0.014	0.008
Four-Year Dist.	0.17	0.019
Two-year Dist.	0.054	0.021
Weeks Absent	0.108	0.006
School-HSA Pass Pct	0.019	0.008
School- Number of CTE Programs	0.315	0.012
School-FARMS Pct	0.035	0.008
Chi-sq	12719.95	22.065
df	45	43
p-value	0	0.997

[11] More information on each of these career clusters can be found at http://www.marylandpublicschools.org/programs/Pages/CTE-Programs-of-Study/Clusters/index.aspx

Table A.3 Propensity Score Matching Effects on Workforce Wages (Wages Imputed)

	Dependent variable:	
	6 years after high school	First Employment
	(1)	(2)
CTE Completion	1,029	726
SE	(280)	(260)
95% Confidence Interval	(427, 1632)	(140, 1311)
Observations	9,656	9,656

Table A.4 Instrumental Variable Estimation of the Effect on Enrollment One Year After High School

	Dependent variable:				
	CTE Completion	Two-year Enroll. (1 year later)		Four-year Enroll. (1 year later)	
	(1)	(2)	(3)	(4)	(5)
Log(distance)	-0.023***	-0.005**		0.005**	
	(0.002)	(0.002)		(0.002)	
CTE Completion			0.222**		-0.219**
			(0.100)		(0.103)
Dep. Mean	0.129	0.284	0.284	0.513	0.513
Observations	29,885	29,885	29,885	29,885	29,885

Table A.5 Instrumental Variable Estimation on Degree Receipt

	Dependent variable:						
	CTE Completion	Associate's		Bachelor's		Certificate	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log(distance)	-0.023***	-0.0004		0.007***		-0.004***	
	(0.002)	(0.002)		(0.002)		(0.001)	
CTE Completion			0.017		-0.285***		0.160***
			(0.078)		(0.103)		(0.040)
Dep. Mean	0.129	0.138	0.138	0.518	0.518	0.029	0.029
Observations	29,885	29,885	29,885	29,885	29,885	29,885	29,885

Table A.6 Instrumental Variable Estimation on Wages

	Dependent variable:				
	CTE Completion	Wages 6 Years Later		Wages at First Employment	
	(1)	(2)	(3)	(4)	(5)
Log(distance)	-0.021***	-418**		-315**	
	(0.003)	(177)		(157)	
CTE Completion			20,434**		15,420*
			(9,138)		(8,017)
Dep. Mean	0.129	0.19	0.19	23242	18003
Observations	14,720	8,962	8,962	8,962	8,962