Analyzing the Effects of CTE Grant Funding on CS Course Offerings and Enrollment in California

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ABSTRACT

Computer Science (CS) courses classified as Career Technical Education (CTE) make up over half of all CS courses offered in high schools in California as of the 2018-2019 school year and are eligible for funding through CTE grants. There has been a growing focus on creating equitable access to CS as well as recommendations to use CTE funds for this purpose. This paper examines whether there is an increase in CS course offerings or CS enrollment as an effect of receiving CTE funding in California. Publicly available data from the California Department of Education (CDE) was used to conduct a two-way fixed effects analysis. Results indicate a null effect from these grants on CS course offerings and enrollment. These results raise questions as to other factors that might have played a larger role in the recent increase in CS course offerings and expansion of CS courses classified as CTE.

CCS CONCEPTS

• **Social and professional topics → K-12 education**.

KEYWORDS

Career Technical Education; CS education; school funding; education policy

1 INTRODUCTION

Computing fields are some of the fastest growing occupations in the United States [19] and computer science (CS) education has benefited through increased funding and policy changes. This growth is motivated by the belief that CS curricula can give students skills important across disciplines and in the labor market [14, 22, 23]. However, there are concerns surrounding equitable access to CS education, from having adequate numbers of teachers to equitably distributed funding [5, 13]. To expand equitable access to CS educational opportunities, administrators and policymakers in the US can consider Career Technical Education (CTE), once known as vocational education. Researchers studying funding dedicated to CS education typically focus on funding for professional development or the creation of instructional materials [15, 20]. CTE resources may be used for these purposes as well as allow for other investments to expand CS education, such as computer labs or recruiting teachers with varied certifications. CTE has multiple advantages as a mechanism for expanding CS education because it enjoys dedicated funding streams, has long been used to prepare high school students to be skilled laborers, and courses classified as CTE typically have different teacher authorization requirements that may broaden the pool of potential instructors [7]. For these reasons, advocates of expanding CS education have encouraged schools to take advantage of CTE opportunities [9].

There is some circumstantial evidence that CTE has facilitated the expansion of CS education in California. For instance, CTE funding rates and the number of offered CS courses have tracked each other relatively closely within California's school districts in recent years. In 2015, there was a sharp increase in CTE funding per student, as shown in Figure 1. After years of averaging approximately \$10 per student statewide, CTE funding increased 8-fold by the 2018-2019 school year. At around the same time, CS courses classified as CTE (CTE-CS) increased substantially, nearly tripling from 0.13% to 0.41% of their share of all classes offered in California high schools, as shown in Figure 2. Non-CTE (i.e., standard academic) CS courses did not experience the same growth. The percentage of all high-school courses that were non-CTE CS courses decreased from 2004 until 2012 before increasing more gradually. This is consistent with CS course availability being facilitated by the specific affordances of CTE. Indeed, a majority of CS courses in California's high schools are taught as CTE. Most notably, the Information and Communication Technologies (ICT) CTE career pathway includes 27 courses where students can learn different CS content, and these make up 60% of all CS courses taught in the state as of 2019.

The similar trends between CS course growth and CTE funding increases suggests that expanding CTE funding may have expanded CS access. There does exist a risk that CTE funding could be used to replace non-CTE CS courses with CTE-CS courses, which would fail to produce a net increase in CS courses. However, both CTE-CS and non-CTE CS courses have experienced growth in recent years, allowing for more CS courses than ever before and suggesting that CTE-CS courses are not just replacing existing CS courses. The extent to which CTE funding has been used to expand CS education is not well understood. However, if CTE funding expands access to CS education, more states can replicate this success.

There are some important considerations for increasing the number of CTE-CS courses. First, while some CTE-CS courses can be dual coded as non-CTE CS, most have a focus on providing practical skills rather than providing traditional academic or college preparatory content. This raises potential curricular trade offs that

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need to be considered. Second, CTE courses have different teacher authorization requirements and so depending on the school or district, access to courses might be limited due to teacher availability. Third, CTE courses typically satisfy different graduation or college admissions requirements than non-CTE courses. Schools will therefore need to balance CTE and non-CTE course offerings. It is not obvious that students, the community, or society are better served by pushing CS content into CTE pathways. This may be especially concerning if CS courses crowd out other CTE coursework that would otherwise be valuable for students.

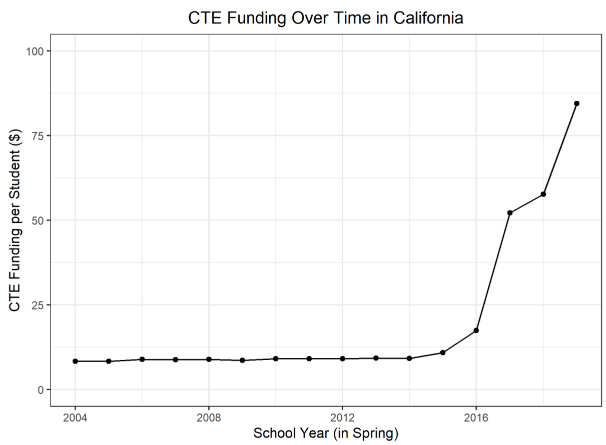

Figure 1: CTE Funding Per Average Daily Attendance Over Time in California

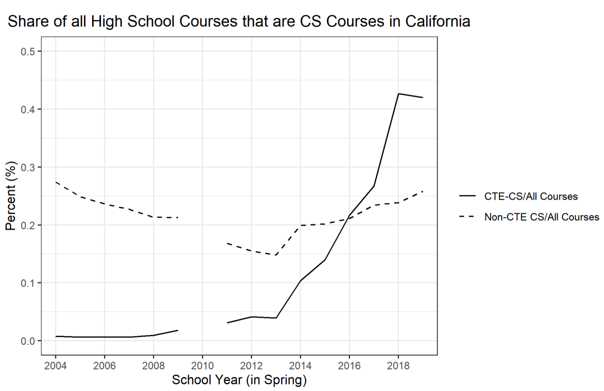

Figure 2: Share of non-CTE and CTE CS courses over time in California. They each make up less than 0.5% of all courses.

These considerations motivate the following research questions:

- **RQ1**: Does CTE funding result in more CS courses being taught in the districts that receive it?
- **RQ2**: Does CTE funding result in increased enrollment in CS courses in the districts that receive it?

Using longitudinal data on school districts' funding and course offerings, we find no evidence that CTE funding is the cause of the recent increase in CTE-CS course offerings in California, or CS offerings generally. CTE funding also does not appear to affect CS course enrollments, even when it is associated with higher CTE enrollments.

2 BACKGROUND

2.1 K-12 CS Education

There is considerable interest in having equitable access to CS for K-12 students. One motivation for this is an increasing need for skilled workers in the computing field, with the occupation of data scientists alone projected as one of the fastest growing occupations of the next ten years [19]. Additionally, computational thinking skills are argued to be a "new basic skill necessary for economic opportunity and social mobility" [11], even for those that do not pursue a career in a computing field.

Since CS is considered such an important part of students' and the economy's future, the underrepresentation of many groups of students in computing in K-12 education is especially concerning. One cause of underrepresentation is disparities in the availability of CS courses in the schools students attend. Data shows "that in the nation as a whole, schools in rural communities and schools with higher percentages of economically disadvantaged students are less likely to teach computer science" [8]. The same report finds that while 89% of Asian and 79% of white high-school students attend schools with a CS course, 76% of Hispanic\Latino\Latina\Latinx students, 73% of Black or African American students, and 59% of Native American or Native Alaskan students do. These disparities highlight the work that still needs to be done to improve access to CS for students in general, and especially for historically underrepresented groups of students.

2.2 Career Technical Education (CTE)

Career Technical Education (CTE), sometimes referred to as vocational education, aims to provide students with knowledge and preparation for direct application in the job market. In the U.S., CTE became a federally funded endeavor in 1917 and was seen primarily as a way to prepare students for the job market [1]. Since the 1980's, significant increases in graduation requirements encouraged students to take more electives, many of which came from those classified as CTE. These new graduation requirements also ensured that even students on a CTE pathway would have to complete what was considered academic track graduation course requirements. Due to this increase in graduation requirements, students were then able to take courses outside of CTE, a CTE intensive pathway, or a combination of the two [2].

Currently, there exist various funding streams for CTE education. The Carl D. Perkins Act was enacted in 1984 with the purpose of improving CTE programs across the nation through funding districts that applied with the intention of maintaining or starting CTE programs. It became the principal source of federal funding for CTE, although local funding streams vary by state. In California in addition to Perkins, three large CTE focused grants impact CS education: the California Career Pathways Trust (CCPT), California's Governor's CTE Initiative program, and the Career Technical Education Incentive Grant (CTEIG) [17]. These grants focus on the implementation of new CTE courses or improvements to a currently offered pathway. Although not applicable to high school CS education, there is pathway-specific CTE funding, like the Agricultural Education Vocational Incentive Grant Program [17], or CTE funding for postsecondary education, such as the Cal Grants [10].

Since CTE can include CS courses, additional funding may support the expansion of CS courses. Indeed, using CTE funding to expand CS course offerings has been highlighted by the NSF-funded Expanding Computing Education Pathways (ECEP) project and the non-profit Code.org's collaborative report in 2016. They suggested that: "States and districts can and should be using the Federal Carl D. Perkins Career and Technical Education Act...to expand equitable access to middle and high school computer science courses as part of a K-12 pathway for students." (p. 1) [9]. Schools with CTE courses are eligible to request and receive funding from Perkins IV to either establish or maintain the course, meaning that available funding sources may be an important determinant of whether schools are able to offer CS courses to their students.

As previously noted, there is some circumstantial evidence that CTE funding has played a role in the expansions of CS education in California high schools to date. Several grants have supported California in increasing the amount of CTE funding per student since 2016. The growth in CS courses classified as CTE within California has also been significant, surpassing the amount of traditional CS courses since 2015 as is seen in Figure 2. One sector within California's CTE program, Information and Communication Technologies (ICT), makes up 60% of all CS courses offered in California for high schools as of 2019. However, statewide correlations between CTE funding and CS course offerings do not make it clear what role, if any, CTE funding is playing in the expansion of CS course offerings.

Understanding the curricular implications of CTE for CS may be relevant for broader CTE research as well. One recent study argued, "the field needs more work to examine critically the new models of CTE delivery, the changes in program offerings (e.g., the addition of information technology, biotechnology, advanced manufacturing), and the mechanisms by which students have come to access them (selective admission, lotteries, school choice)." [12]. Thus, this paper examines changes in CS offerings and one mechanism by which students may have access to them: the district-level decision to apply for CTE grants. While prior research has found positive effects on, or reductions in, dropout rates in districts receiving one of these grants in California [4], there has not been an analysis of their effects on CS course expansion or enrollment. It is unclear whether CTE funding is being used to expand CS education in secondary schools or whether it can be used to relieve districts' capacity constraints.

2.3 Equitable CS Education

There are a variety of barriers that may stand between students and equitable CS educational opportunities. One tool for understanding these barriers and how they are related to each other is the CAPE framework [13]. The CAPE framework organizes the requirements for equitable CS educational opportunities into four categories, each of which serves as a prerequisite for the next: Capacity for, Access to, Participation in, and Experience of CS education.

Capacity reflects that if schools do not have the capacity to offer CS coursework (e.g., in the form of qualified staff or essential technology), then those schools will be unable to provide students with access to CS courses. This lack of access will in turn preclude students from participating in such courses and experiencing effective instruction. In sum, school capacity is fundamental to expanding CS education and the aspect of the CAPE framework most related to the role of CTE funding. *Capacity* to offer CS coursework has been linked to the availability of resources for teacher compensation, teacher professional development, and equipment and facilities costs [13]. As noted above, several dedicated funding streams exist to support CTE and they can be used to support aspects of the CAPE framework. If so, CTE funding may build schools' CS capacity, thereby promoting CS access and participation.

CTE structures may hold some promise for promoting *Access* to CS, as CTE coursework appears to be broadly accessible. For example, 77% of all high school students in the U.S. earned at least one credit in CTE in 2019 [18], meaning that most schools likely have the infrastructure in place to apply for this funding and then use it to offer CTE-CS courses. As for *Participation*, although certain CTE pathways still suffer from underrepresentation of certain groups, including in the ICT sector, CTE student demographics generally reflect the student population [3], while CS student demographics do not [16]. Since CTE courses tend to have more representative student participation than existing CS courses, integrating CTE and CS more closely might facilitate equitable CS participation. There is no direct connection between funding and *Experience* because achieving equitable experiences in the classroom is more dependent on teaching strategies and appropriate curricula. Existing research has yet to examine how students' educational experiences compare across CTE and non-CTE computing courses.

3 DATA

To answer our research questions, we rely on public administrative data from the California Department of Education (CDE), spanning the school years 2003-2004 through 2018-2019. However, we only have the courses and enrollment reported in the fall semester. Our data includes virtually all high schools and K-12 schools in California; we focus on schools serving high school students as this is where CTE is primarily focused and where we can observe the content of individual courses. While a limited number of CTE courses can be taken during seventh and eighth grade, middle-school course content is not as well documented in the CDE data. Due to lack of reliable course data, we exclude district-run schools providing alternative educational opportunities to students, such as community day schools for students that have had problems with attendance or behavior. Charter schools are also excluded because there is less financial data available for them and they are generally substantially autonomous even from those school districts with which they are formally affiliated [21]. In total, the data analyzed for this study includes 410 school districts.

3.1 Course Data and Classification of Courses as CS

Our outcomes of interest are CS course offerings and enrollments, which we observe in course assignment data released by the state for all years except 2009-2010. These data are provided to the CDE by school districts each fall and provide a list of each course offered and the number of enrolled students. Each course is classified with a code that indicates its title, category, and course description, along with whether the course is classified as advanced placement (AP) and/or CTE. We created a category for CS using a categorization scheme from prior work that analyzed trends in CS in California high schools [5]. Under this classification scheme, courses were classified as CS if their course descriptions indicate programming content even if they do not specifically have 'computer science' in the name. Using this method, twenty-eight courses from ICT or Manufacturing and Product Development (another one of the CTE pathways) are classified as CS. For this analysis, any CS course that was classified as CTE by the CDE was labeled CTE-CS and ten other courses, not classified as CTE, fall under all CS courses. However, though some schools use AP CS courses as the final course in a CTE pathway, these are not coded as CTE, and it is difficult to distinguish them. Consequently, we classify AP CS courses as non-CTE CS.

After restricting our sample of schools as described above, we construct two course outcomes that correspond to our two research questions. First, we construct the percentage of CS courses in the district. That is, we divide the number of CS courses offered by the total number of courses offered, and multiply by 100. Second, to get a clearer picture of course participation — distinct from course availability — we construct the percentage of enrollment in CS courses in the district. To construct this measure, we added up all course enrollments in the district, across all courses, as well as all enrollments in CS courses specifically. We then divide the latter by the former (and multiply by 100).

CDE includes the number of students in each course as well as the number of students in the entire school. Since the data does not include student-level identifiers, and some schools offer more than one type of CS course, we cannot determine if a single student is enrolled in multiple CS courses. It is therefore possible that in the calculation of student enrollment in CS may be slightly elevated as some students could be counted for more than once. This could result in an overestimation of the effect of CTE funding on student enrollment in CS, CTE-CS, and CTE courses. However, this is unlikely to be a significant overestimation as courses in a CTE pathway are typically taken sequentially and this limits the possibility of a single student's simultaneous enrollment in multiple CTE-CS courses. Additionally, the fact that we do not observe courses offered later in the year (e.g., in the spring semester) means that our picture of course offerings and enrollments is incomplete. However, previous research has shown that these fall data nevertheless show considerable CS course growth during this time [6].

3.2 Financial data

Our research questions concern the influence of CTE expenditures in dollars, which we obtain from annual financial records reported by districts to the state each year using a standardized account code structure (SACS). Both CTE revenue and expenditure are provided, but in this paper we focus on CTE expenditure. Specifically, given our interests in the potential for CTE to open up additional funding streams for CS education, we consider expenditures made from resources provided by the Perkins program for secondary students, California's Governor's CTE Initiative program, and the CTE Incentive Grant program. While districts will sometimes spend less than the funding they receive, the money spent per pupil has the largest potential for impact on course offerings and enrollment. Additionally, funding from some grants can be used in the next year, and this ensures that some funding is not accounted for twice. To account for the size of the student population served by the district, we divide CTE expenditures each year by total enrollment to obtain dollars of CTE spending per pupil in the district. In our regressions, we divide this figure by 100 so that results can be interpreted as the change in courses or enrollments associated with an additional $100 per pupil in CTE spending, a more substantively significant quantity roughly on the order of mean CTE spending by districts in California during this period.

3.3 Other school-level data

Finally, the CDE releases annual school-level data on student demographics, which serve as control variables in our analysis (See Section 4). Specifically, we use student eligibility rates for free or reduced-price lunch as an indicator of student socioeconomic status. We also obtain student racial demographics. As previous work has shown, these are important correlates of CS course access and participation [8, 13, 16]. Summary statistics for all variables are shown in Table 1.

4 METHODS

To assess the relationship between CTE funding and CS course offerings and enrollment, we estimate two-way fixed effect (FE) models of the following form:

$$\%CS_{dt} = \beta_1 CTE_{dt} + X_{dt} + \gamma_t + \delta_d + \epsilon_{dt} \tag{1}$$

In model 1, %CS represents either the percentage of courses or the percentage of course enrollments represented by CS courses, as described above, in district d in year t. In some specifications, we also consider CTE courses separately or CTE-CS courses specifically. Our predictor of primary interest is CTE, or CTE expenditures in the district of 100s of dollars per pupil. We then take several approaches to isolate the relationship between CTE spending and CS courses that is not explicable in terms of other factors. First, we take advantage of the longitudinal nature of our data to control for district FEs, accounting for average differences between districts. This effectively compares districts to themselves over time, as they spend more or fewer CTE dollars. Second, year FEs account for changes common to all districts each year (e.g., general price inflation or statewide regulatory changes related to curricula). These FEs collectively address many potential unobserved sources of bias in our estimates, but cannot account for factors varying within districts over time in ways correlated with funding and curricula. We thus include a vector of time-varying district controls (X), including the percentage of students receiving free or reduced lunch, and the percentage of underrepresented minority students, which in this case refers to students that are neither white nor Asian. These controls are important as student economic status and race have been predictors of opportunities for CS education [8, 13, 16]. Because we observe districts repeatedly over time, we cluster standard errors on districts. This is a conventional approach to dealing with a lack of independence between observations in the sample. However, it is worth noting that the sampling uncertainty normally quantified by standard errors does not necessarily apply because we observe

Table 1: Summary Statistics

	N	Mean	SD	Min	Max
CTE Spending ($/Pupil)	6435	64.86	156.05	0.00	3733.58
Percentage of Courses that are CTE CS	5972	0.20	0.64	0.00	10.77
Percentage of Courses that are CTE	5972	9.23	6.77	0.00	64.15
Percentage of Courses that are CS	5972	0.44	0.81	0.00	10.77
Percentage of Enrollments that are CTE CS	5972	0.17	0.59	0.00	10.61
Percentage of Enrollments that are CTE	5972	7.84	5.36	0.00	63.87
Percentage of Enrollments that are CS	5972	0.38	0.76	0.00	10.61
Percentage of Students Receiving Free or Reduced-Price Lunch	6506	0.47	0.24	0.00	1.00
Percentage of Students who are neither White nor Asian	6506	0.54	0.25	0.00	1.00

Note. Includes annual observations of 410 districts between 2004 and 2019. CTE = Career technical education. CS = Computer science.

the near-universe of school districts in California that serve secondary students. We therefore focus primarily on direction and magnitude of our point estimates, rather than their statistical significance, while also being cognizant of the difficulty of generalizing our results to contexts outside of California.

5 RESULTS

Table 2 shows the relationships between CTE expenditures and our six outcomes, estimated from Equation 1. Unsurprisingly, but reassuringly, we find that there is a positive and substantively meaningful relationship between CTE spending and CTE course offerings and CTE enrollments. Specifically, an additional $100 of CTE spending per district pupil is associated with CTE courses accounting for an additional 0.16 percentage points of all courses (column 2) and an additional 0.15 percentage points of all course enrollments (column 5). These estimates do not reach statistical significance, but, as noted, above sampling error is a relatively minor concern in our context because we include a near-universe of school districts in California that serve secondary students. However, we find no evidence that CTE expenditures result in more CS education. CTE spending is almost entirely unrelated to the share of all courses that are CTE-CS courses, specifically (column 1). Further, when we consider all CS courses, the relationship is very slightly negative (column 3). These patterns are nearly identical when we examine the percentage of course enrollments that are in CTE-CS courses (column 4) or any CS course at all (column 6).

This pattern of results suggests that while CTE curricula may be providing students with expanded CS educational opportunities - recall that CTE courses represent a large portion of all CS courses in California - this is not to a large degree driven by the dedicated CTE funding streams we consider here. Rather, those CTE-CS expansions may be made possible by other (e.g., general purpose) funding or driven by other, non-funding considerations (e.g., related to teacher recruitment and retention issues arising from varying teacher certification requirements between CTE and non-CTE programs). Relatedly, our results do not suggest that these grant programs supporting CTE-CS courses crowd out non-CTE CS courses to a significant degree.

Though not of primary interest here, it is also worth noting that CS courses and course enrollments are consistently negatively (though mostly not statistically significantly) related to our measures of student disadvantage or potential marginalization (subsidized lunch eligibility and race). This is consistent with the evidence, discussed above, that access to CS educational opportunity is inequitably distributed along race and class lines. Indeed, it is particularly troubling that these negative relationships persist even net of district fixed effects (i.e., within districts over time).

6 DISCUSSION

Contrary to our hypotheses, we find no evidence that CTE funding is associated with expanded CS curricula or participation. Our estimates of the effect of CTE funding on CS are not only statistically insignificant, they are very small in practical terms. This is true whether we predict CS course offerings or CS enrollment or whether we focus separately on CTE-CS courses or CS courses generally.

We cannot rule out the possibility that the CTE funding streams considered here play some role in sustaining CS courses in schools already offering these courses. It is possible that CTE investments funded in other ways, such as with unrestricted aid, have been important contributors to recent CS educational expansions. However, our results indicate that these CTE funding streams are not, at current margins, a major factor driving the recent increase of CS courses and CS course participation.

This does not necessarily imply that advocates of CS education are wrong to appeal to CTE funding as a mechanism by which CS curricula can be expanded. Rather, our results may indicate that these funding streams have simply yet to to be heavily used for such purposes. Similarly, we do not find evidence that these funding streams are crowding out non-CTE CS courses in favor of CTE-CS courses. However, should CTE funding streams be used more systematically to fund CS expansions, care should be taken to not reduce non-CTE CS course offerings as a result.

At a minimum, our results underscore the importance of determining what factors are driving administrative decisions about whether and how to expand CS educational opportunities for students. CTE may still be a useful avenue through which to pursue CS educational expansions and to do so equitably. However, it appears that their role in this domain has been limited. By the same token, CTE-CS education has expanded rapidly in California in recent years, and the policy and administrative drivers of this expansion

Table 2: CS, CTE, CTE-CS course offering and enrollment predictors

	Percentage of Courses			Percentage of Enrollments		
	(1)	(2)	(3)	(4)	(5)	(6)
	CTE CS	CTE	CS	CTE CS	CTE	CS
CTE Spending ($100s/Pupil)	0.00	0.16	-0.02	0.01	0.15	-0.01
	(0.01)	(0.13)	(0.01)	(0.01)	(0.12)	(0.01)
Percentage Free or Reduced-Price Lunch	-0.12	-1.15	-0.35*	-0.11	-1.68	-0.34+
	(0.11)	(1.28)	(0.17)	(0.11)	(1.07)	(0.18)
Percentage neither White nor Asian	-0.16	1.96	-0.33	-0.26	2.00	-0.42
	(0.25)	(3.35)	(0.37)	(0.25)	(3.13)	(0.34)
District FEs	X	X	X	X	X	X
Year FEs	X	X	X	X	X	X
Observations	5900	5900	5900	5900	5900	5900
Districts	410	410	410	410	410	410
R-sq.	0.41	0.68	0.43	0.33	0.71	0.39
Adj. R-sq.	0.36	0.65	0.39	0.28	0.68	0.34

Note. Standard errors clustered on districts in parentheses. CTE = Career technical education. CS = Computer science. FEs = Fixed effects.

+ p<.1, * p<.05, ** p<.01, *** p<.001

are not well understood. This is only underscored by our inability in this study to find support for the theory that these CTE-specific revenue streams have played a major role.

7 LIMITATIONS

While the longitudinal nature of our data allows us to account for many unobserved potential sources of bias in our estimates, as well as some time-varying district characteristics, we cannot rule out the possibility that our estimates are affected by unobserved factors varying within districts over time in ways associated with both CTE funding and CS courses. Additionally, while we considered the creation of additional course offerings and new enrollment, we did not analyze the effects of this funding on sustaining existing courses. Our results cannot be generalized to other contexts as education policies, and especially school and CTE funding policies, may differ across states in ways that have important implications for the relationship between CTE funding streams and CS curricula. It is possible that in some states CTE funding has been used to increase CS courses and CS enrollment. These unexpected results suggest that it would be valuable for those looking to expand CS to look into how CTE funding and CS courses might relate in other states.

8 CONCLUSION

The primary contribution of the paper is to determine if CTE funding in California from 2003-2018 was associated with a substantial increase in CS or CTE-CS course offerings or enrollment. The funding streams we consider are not associated with any change in CS or CTE-CS course offerings or enrollments. These results suggest that these funding streams may continue to have untapped potential for funding CS educational expansions, as advocates of those expansions have sometimes argued. Results also indicate that there may be other factors playing a larger role in recent secondary CS educational expansions that should be studied in future work.

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