Academic Impacts of Career and Technical Schools

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Abstract

This study presents findings from three cohorts of students – the classes of 2003, 2004, and 2005, in the School District of Philadelphia – that were admitted to the district's career and technical education (CTE) schools through a randomized lottery process. This study takes advantage of this so-called "natural experiment" to compare high school academic outcomes for lottery applicants who were admitted with those for students who did not receive an acceptance. Results find that CTE students had significantly better outcomes in terms of graduation rates, credit accumulation, and the successful completion of the college preparatory mathematics sequence algebra 1, algebra 2, and geometry. Results for other outcomes such as the completion of science and foreign language course sequences, overall grade point average, and mathematics and reading comprehension achievement, were inconsistent across cohorts and statistical tests, neither favoring nor against students accepted to CTE schools.

Keywords: academic impact, career and technical education, concentrators

Introduction

With growing public recognition that too many students in the United States fail to complete high school and that those who do graduate are often inadequately prepared for success in postsecondary education and the workforce, policymakers and education leaders are turning their attention afresh to the American high school. Within the past decade, public investments and private donors have sought to remake the high school in various ways: by organizing high schools around unifying themes, creating improved curricula for students who enter high school underprepared, developing standards and end-of-course exams, breaking larger high schools into smaller units, and creating small autonomous schools.

Despite this flurry of activity, there has been relatively little public discussion about the role of Career and Technical schools in preparing students to enter higher education and the workforce. More than 80% of the approximately 21,000 public high schools in the United States offer some type of career and technical education course (NCES, 2008). However, for the over 1,400 high schools known as "career and technical high schools" (CTE schools), workforce preparation is the central and primary mission.

The fundamental research question that this paper seeks to answer is: *What is the effect of career and technical schools on high school students' academic outcomes?* This question differs in subtle but important ways from the questions that researchers typically have asked about the effects of career and technical education. Much of the research, including the work that we review below, has examined whether CTE *coursework* has an impact on outcomes such as graduation rates or mathematics achievement—regardless of the type of school in which the CTE courses

are taken. Our work differs from these analyses by examining outcomes in which the school itself is the intervention.

There are several arguments for gathering evidence on the achievement and graduation effects of *schools* that are devoted exclusively to CTE (as opposed to CTE coursework offered in comprehensive high schools). First, given the importance of preparing students both for work and additional post-high school education, it is useful to know whether CTE schools decrease the probability that students will complete rigorous academic coursework necessary for postsecondary success. Critics of vocational education have argued that workforce preparation courses historically have been an academic "dead-end," limiting student access to and success in rigorous academic coursework. Taking courses that are career-focused involves some opportunity cost: less time in the school day to prepare for or to study advanced mathematics, science, or foreign language. At CTE schools, the focus on preparation for work could result in less academic press for college-preparatory coursework and fewer course offerings in advanced academic subjects.

At the same time, proponents of career and technical education have argued that courses related to students' occupational interests may serve as a "carrot" for them to attend school and to engage – at some level – with academic content that they might view as less relevant and appealing. Some students, particularly early on in their high school careers, may view doing well (or well enough) in their academic classes as an investment that they need to make in order to take the career and technical courses they desire. Further, at schools that do a good job of showing students how academic content relates to their occupational interests, students may develop intrinsic motivation for doing well in mathematics, science, and other academic subjects. If CTE schools are able to engage students at an earlier point in high school through career-focused coursework – and if they are able to provide this "hook" because their specific institutional mission is CTE education – then there may be a good argument for supporting stand-alone CTE schools, in addition to or instead of CTE coursework at comprehensive high schools. A related argument is that by moving more quickly to demonstrate the connection between what students are learning in school and what they can do in the workplace after high school, CTE schools may increase the percentage of students who earn a high school diploma.

Each of the arguments for investigating the effects of CTE schools suggests a mechanism by which attending a CTE school may be linked to more positive (or negative) academic outcomes for students. The primary purpose of this paper is to establish whether there is an association between attending CTE schools and student outcomes. If so, providing more opportunities for students to receive CTE schooling may be another lever for increasing high school graduation rates. To examine these possible associations, we analyze data from a natural experiment in the School District of Philadelphia where students entered into a random lottery process for admission into one of the district's several career and technical high schools. Specifically, this paper examines outcomes for the classes of 2003, 2004, and 2005 (that is, students who began high school in the fall of 1999, 2000, and 2001, respectively), for whom data was available. Although we present descriptive information that may provide suggestive evidence about these mechanisms, it is beyond the scope of this study to provide a rigorous assessment of *how*, if at all, CTE schools affect student outcomes. Given the dearth of information on the effects of CTE schools and the challenge of establishing credible comparison groups,

we focus instead on establishing the existence and magnitude of any such effects.

Prior Evidence on the Effects of Career and Technical Education

One of the goals of career and technical education is to engage students in their education by making clear the connections between what they are learning in their classes and their occupational interests. If students come to understand that what they are learning in chemistry or mathematics will be useful in their future careers, they may be more willing to put in the work needed to learn the material and earn passing grades in these classes. Alternatively, if they enjoy their career and technical classes, they may be more inclined to tolerate their academic classes even if they still find the connections with their future difficult to discern. Seeing some future benefit to completing high school classes – particularly academic classes – may be especially important for students who arrive in high school with a negative view of school and/or of themselves as capable learners. Students' engagement in schooling is demonstrated, at a minimum, by attending school and accumulating at least some course credits. Ultimately, engagement in schooling should lead to high school graduation – if not "on-time" (within four years), then within five or six years after entering high school.

Previous research on the effect of CTE or vocational coursework on graduation rates (or dropout rates) has produced mixed evidence, with some finding a positive effect, others observing negative effects, and a third group finding no impact. Using data from the High School and Beyond study, Arum (1998) found that vocational course work increased the odds of earning a high school diploma, a finding mirrored in a 2006 analysis by Cellini, using data from 1997 National Longitudinal Survey of Youth (Cellini, 2006). A study by Plank, DeLuca, and Estacion (2008) adds more nuance to the debate. These researchers argue that graduation rates are higher among students who have taken a mix of vocational and academic courses in a ratio of three to four. In contrast, a study by Ainsworth and Roscigno (2005) that used data from the National Educational Longitudinal Study found a negative effect on graduation rates of "blue collar" vocational course work. A third group of studies finds no effect of CTE coursework on graduation rates. Using data from the Education Longitudinal Study (ELS), Bozick and Dalton (2013) found that there is a negligible effect of occupational course taking on high school completion or mathematics achievement. However, it should be noted that students must have been promoted to tenth grade to be in the ELS. This feature of the study means that in large urban districts, where many of the most at-risk students are never promoted to tenth grade, an important subgroup of eventual dropouts is excluded from the study.

The evidence on the effect of CTE course taking on academic growth as measured by standardized test scores is much more consistent than its effect on graduation. In short, there is good evidence that students who are *vocational concentrators,* or *dual concentrators* (students who took both college preparatory and career-related coursework) experience smaller learning gains in mathematics or reading comprehension than *academic concentrators* (with few or no CTE courses) (Kaufman, Bradby, & Teitelbaum, 2000; Plank, 2001). Given that vocational concentrators do not take the same college-preparatory course sequences as academic concentrators, it makes sense that they would not experience the same learning gains in academic subjects (although they might experience greater learning gains in CTE subjects). However, there is evidence dual concentrators have greater gains than vocational concentrators

(Agodini, 2001). A recent study comparing cohorts over the past three decades found a national trend of decreasing vocational concentrators matched by an increase in overall CTE course taking and dual concentrators (Dalton, Lauffe, Henke, Alt, & Li, 2013; National Assessment of Career and Technical Education, 2013). This study also found that as academic course taking has increased amongst all students, occupational course-takers had increased their achievement levels and post-secondary enrollment rates over the past three decades at a higher rate than the occupational non-participants, closing the gap somewhat.

Given the evidence that academic concentrators appear to out-perform those who are dual concentrators, it is plausible that CTE schools may be associated with smaller learning gains in academic subjects. That is because students at the CTE schools in this study are dual concentrators (taking courses in both academic and career-related subjects), while those at other schools are a mix of dual concentrators or academic concentrators. As all students at Philadelphia CTE schools were required *by the school district* to take and pass college-preparatory academic courses for promotion and graduation, theoretically at least, there were no students who were vocational concentrators in the Classes of 2003 through 2005.

While there has been considerable work on the effects of CTE course taking, there is relatively little research that addresses the impact on academic outcomes of attending a career and technical high school. The studies cited above examined the former and compared outcomes for students who took vocational or CTE courses with those for students who did not take such courses. In contrast, the current study compares outcomes for lottery students accepted to CTE schools to those of students who were not accepted, but who nevertheless may have taken CTE courses at the school

they ultimately attended. Although prior research has not examined the effects of CTE schools *per se*, several studies have considered the impact of career academies. Career academies typically are not physically or administratively separate schools, but rather career-related programs housed at comprehensive high schools. Often students must apply to participate in a career academy.

One study of this type examined the impact on graduation rates of "opting out" of a neighborhood high school to attend a career academy in the Chicago Public Schools (Cullen, Jacob, & Levitt, 2000). The researchers found that students who opted out of their neighborhood high school to attend a career academy had increased odds of completing tenth grade, completing eleventh grade, and graduating from high school; at the same time, students who were assigned to a career academy because of geographic residence also experienced these benefits. The fact that a subgroup of career academy students was selected by lottery to attend these schools adds to the strength of the argument that there was something about the curriculum, climate, or other features of these academies that had an impact on student attainment. This Chicago analysis did not provide an empirical exploration of the reasons why career academies were associated with higher promotion and graduation rates.

A rigorous national evaluation of career academies (small schools-within-a-school at comprehensive high schools), which used randomized assignment, found that among students who were at high risk of dropping out of high school, the career academies substantially increased their attendance, academic course-taking, credits earned toward graduation, and on-time graduation rates. Graduation rates also increased among students who were least likely to drop out of school. When the data for all career academy students was pooled,

however, there was no statistically significant effect of the academies on the rates at which students graduated from high school or earned a GED (Kemple, 2004; Kemple & Snipes, 2000). Further, the career academies did not increase scores on standardized tests in reading and mathematics. However, a second study of career academies, which also used random assignment, found that participating in the career academies had a negative effect on graduation rates (Crain et al., 1999). The researchers hypothesized that the academic standards of the career academies, combined with the lack of academic support, could have contributed to the lower graduation rates of the academies. Beyond high schools outcomes, follow-up studies found that career academies produced positive and sustained impacts on labor market outcomes such as average monthly earnings (Kemple & Willner, 2008).

Context of Career and Technical Education in Philadelphia

During the 2004-2005 school year - the on-time graduation year of the third cohort of students examined in this study - the School District of Philadelphia was the tenth largest school district in the United States, with 187,547 students (Garofano & Sable, 2008). Like many other large urban school districts, the district served a population of students that was mostly minority and mostly from low-income families. During 2004-2005, 86% of the students in Philadelphia's schools were members of minority groups, and 69% were eligible for free or reduced price lunch (Garofano & Sable, 2008). Approximately 65% of the students were African American, 15% were Latino, 5% were Asian, and 15% were White (Garofano & Sable, 2008). Of the School District of Philadelphia's 270 non-charter schools during 2004-2005, 44 were high schools (Garofano & Sable, 2008). During the time period covered by this study, most students attending non-charter high

schools in Philadelphia attended the local neighborhood high school that was their "default" high school based on geographical area of residence. Students who took advantage of the school choice options were permitted to apply to other schools throughout the city, including either special admissions schools (otherwise known as "magnet" schools) or CTE schools.

Special admissions were permitted to select students based on their seventh and eighth grade course marks, attendance, behavior marks, and test scores, as well as an interview or audition if required. When the cohorts that are the focus of this report were applying to high schools, special admissions schools included competitive exam schools that were founded in the mid-19th century; schools that were established more recently and offered themes such as engineering, international study, or the arts; and schools without a specific theme that offered college-preparatory curricula. The specific student achievement levels and other criteria required for admission varied from school to school.

CTE schools provided career-related education in addition to traditional academic subjects. All eighth graders applying to be part of the class of 2003 were entered into a lottery, but for the classes of 2004 and 2005, the CTE schools were permitted to shape their lottery by first screening students for previous achievement and attendance, and then conducting the lottery. For the classes of 2003 and 2004, students could apply to one or more of four CTE schools, and the class of 2005 could apply to one or more of these four schools, plus an additional fifth school that had become an independent entity and accepted students from throughout the city. CTE schools in general can offer programs focusing on a wide range of training, each with their own purpose. Four schools in this study offered an array of traditional CTE electives along with courses of study that reflected 21st Century technologies and/or job

categories that were expanding in the Philadelphia. These included: auto mechanic; building trades; business education; child care; computers; cosmetology; food services; graphics; health occupations; hotel, restaurant, travel and tourism; and transportation. The fifth school provided a focus on agriculture and animal care.

During the time period covered by this report, all of the neighborhood high schools offered some courses that can be categorized as career/technical education (for example, accounting). However, while students at the districts' neighborhood schools were able to enroll in CTE courses, they did so at far lower rates and with systematic differences in that their courses were not of the occupational preparatory nature of those offered at CTE schools. Importantly, nearly all of the CTE course offerings at CTE schools were Occupational Education courses relating to specific marketable skills. In contrast, the CTE courses offered at neighborhood high schools were typically general labor market preparation classes, developing skills that are not applicable to one specific occupational area, such as keyboarding, computer literacy, and searching for jobs, or family and consumer science courses entailing subjects such as parenting skills, home economics, and domestic maintenance, that prepare students for family life. This gives us confidence that the education offered at CTE schools was of a substantive and qualitatively different nature than that offered by the regular neighborhood schools.

Table 1 summarizes key data for the three categories of non-charter high schools. Of note is that, in terms of the percentage of students eligible for free and reduced lunch and the racial/ethnic distribution of the student body, the CTE schools are much more similar to neighborhood high schools than to special admit schools. Also, while CTE schools in other school districts across the country may typically be characterized as smaller schools, the five Philadelphia CTE schools observed in this study were quite large with an average enrollment of 1,000 students. This is equivalent to the district-wide average for all regular, special admission, and charter high schools to which students not admitted to a CTE school could have attended and which thus provide the comparison in the analyses below.

Table 1

Descriptive Data for Public High Schools in Philadelphia, by School Type, 2004-2005.

	CTE Schools	Special Admission	Neighborhood	District Total
Schools (*n*)	6	16	25	64
Students (*n*)	5,394	9,822	39,629	65,446
Free/reduced lunch (%)	60.1	15.3	63.1	48.2
Race				
African American (%)	70.1	57.2	67.7	64.2
Asian (%)	3.2	12.3	5.6	5.9
Latino (%)	11.5	5.7	14.2	14.2
White (%)	15.0	24.6	12.2	15.5

SOURCE: Common Core of Data, 2004-2005, National Center for Education Statistics

High School Application and Admission Process

Each fall, the high school choice process begins for Philadelphia eighth graders who plan to attend public high schools or who are considering the public schools as an option. The high percentage of students who apply to one or more high schools indicates that school choice has become a normalized part of the transition to high school in Philadelphia. Among students who were eighth graders in the Philadelphia public schools during 1998-1999 (potential members of the class of 2003), 70% applied to at least one high school outside of their attendance zone. For eighth graders in 1999-2000 and 2000-2001, the percentages were 69% and 62%, respectively. Research on subsequent cohorts of Philadelphia's incoming ninth grade students indicated that this downward trend was an aberration, as rates of students applying to schools outside of their attendance zones have recently increased, reaching 65% for the class of 2007, and 73% for the class of 2010 (Hartmann et al., 2009).

One feature of note is that students were permitted to apply to multiple schools or programs. The number of schools to which students were permitted to apply varied from cohort to cohort. For the classes of 2004 and 2005, we observe in our data that some students applied to as many as ten high schools. For the class of 2003, some students applied to as many as 16 choices. This large number of applications for the class of 2003 was due in part to a feature of the application process that year that permitted students to apply to multiple lottery-based programs within the same school. Second, students were asked to rank their school choices in terms of preference. All else being equal, a student who indicated that a particular school was their first choice had a better chance of being admitted than a student who indicated that the school was a lower-ranked choice on his list of preferred schools.

After student high school application forms were submitted, individual schools and the district began the process of determining which students would receive offers of admission. Students were admitted to high schools through several types of processes. The way in which an admissions decision was reached depended on the categories of schools to which students applied. Special admissions schools made their own admissions decisions after screening applicants on the basis of previous academic achievement, attendance, and school behavior, and sometimes an interview and/or audition; lottery-based programs made admissions decisions randomly from their pool of lottery applicants.

For the class of 2003, all students who applied to a lottery-admissions based school were entered into the lottery, regardless of prior academic achievement, attendance, or behavior; there was no initial screening to make sure that applicants in the lottery pool met any particular criteria. The lottery was conducted using a computer algorithm that took into account student racial/ethnic background in order to promote racial balance (see below). A lottery for each school was first conducted for students who ranked that school as their first choice. Students who were admitted to their first-choice school or program were taken out of the lottery for any subsequent choices they listed; students could receive only one offer of admission to a lottery-based school or program. After this first round of the lottery was conducted, any student who did not receive admission at their first choice school and who had indicated a second choice school was entered into a second round of the lottery. If a student was not a "winner" in the second round, then the lottery tried to place students in their third-choice school. This process was repeated for as many choices as students had made, up to the maximum number allowed (in years when a maximum was stipulated).

For the classes of 2004 and 2005, the admissions process for at least some lottery schools had two stages. The CTE schools that are the focus of the paper used this two-stage process. The first stage was the *crafting of the lottery pool* through a "pre-screening' of applicants before conducting the lottery. At this stage, applicants were screened by the individual schools for having requisite academic, attendance, and behavioral characteristics and, sometimes, based on their interest in the career fields offered and/or performance in an interview. In the second stage, *the lottery was conducted for students who had been "screened in" to the lottery*. At some schools, 50% or more of the applicants were screened out on the basis of prior achievement before the lottery was conducted, thereby creating a more academically select lottery pool. Although it is important to be clear about the group of students to which results from the different classes may be generalized, the students nevertheless were offered admission through a random selection method.

Regardless of whether the high school selected students on the basis of previous achievement and behavior or used a lottery to admit students, all schools were required to seek racial balance. This requirement stems from a series of court orders starting in 1972. Philadelphia's main strategy for creating racially balanced public schools has been its option for parents to seek school transfers for their children. This requirement of seeking racial balance means that student racial/ethnic background is taken into account in determining which students will be admitted. Previous research on acceptances at special admissions schools shows that White students, who are a numeric minority in the public schools, have higher odds of being admitted to a special admissions school, all else being equal (Neild, 1999). Regressions predicting acceptance to a CTE school for the classes of 2003, 2004, or 2005 show that the only set of student characteristics that consistently predicts acceptance is racial or ethnic background. We do not have the access to the specific formula that the district used to admit students based on their racial or ethnic background.

Comparisons of Career and Technical School Applicants in Philadelphia

By almost any measure, the CTE schools in Philadelphia were a strong draw among rising ninth graders. Although it is not clear how much students were interested in CTE schools because they hoped to escape chaotic or dangerous neighborhood high schools or because they were genuinely interested in the career and technical offerings of the schools, what *is* clear is that the schools were substantially oversubscribed. Among students who were eighth graders during the 1998-1999 school year (and who, therefore, were potential members of the class of 2003), 43% (a total of 6,647 students) applied to at least one CTE high school; among those who applied to any school (including special admit schools and neighborhood high schools), 61% applied to a CTE school. The percentages were similar for the classes of 2004 and 2005: 42% (8,825 students) and 43% (5,371 students) of all eighth graders, respectively, applied to at least one CTE school.

When the demographics of applicants to CTE schools as a group are compared to those of non-applicants, it is clear that while there are some notable demographic differences, there are relatively small differences in terms of prior academic achievement. In other words, as a group, CTE applicants are broadly representative of students as a whole in the school district, at least in terms of observable academic characteristics. They are not the weakest students, nor are they the "cream of the crop." Table 2 shows that a higher percentage of

CTE applicants compared to non-applicants were African-American and a smaller percentage were Asian or white. Hispanic students were represented more or less equally within CTE applicants and non-applicants. While not shown in Table 2, applicants to CTE schools were almost evenly divided between males and females (just over 50% female for all classes).

Table 2

Comparison of Students by Cohort and Application to a Career and Technical School

	Class of 2003		Class of 2004		Class of 2005	
	CTE	Non	CTE	Non	CTE	Non
Students (n)	7,024	9,902	7,428	11,273	7,842	10,966
Race						
African American (%)	72.7	60.6	72.3	61.6	69.2	62.9
White (%)	12.6	21.2	12.5	20.9	14.8	19.1
Hispanic (%)	10.7	11.9	11.3	11.8	11.7	10.6
Asian-American (%)	3.8	6.1	3.7	5.6	3.7	7.1
Other (multi-racial) (%)	0.3	0.2	0.2	0.2	0.6	0.3
Academics						
8th Grade GPA	2.18	2.17	2.36	2.32	2.53	2.44
Reading						
Advanced (%)	2.1	4.2	1.8	4.2	1.9	3.3
Proficient (%)	15.8	18.3	14.3	17.2	18.8	19.1
Basic (%)	25.5	24.4	24.3	23.2	28.1	24.0
Below Basic (%)	56.6	53.1	59.6	55.3	51.2	53.7
Math						
Advanced (%)	1.2	2.9	1.2	2.8	1.3	2.8
Proficient (%)	10.0	12.6	10.4	13.1	12.0	12.7
Basic (%)	18.1	18.0	15.0	15.3	22.5	20.8
Below Basic (%)	70.8	66.5	73.5	68.8	64.3	63.8

Study Design and the Evaluation of CTE

We take advantage of the natural experiment in Philadelphia in which applicants to the city's career and technical high schools were randomly selected to receive an offer of admission, to examine the effect of CTE schools on a range of academic outcomes for students. Specifically, we address the following research questions:

- What is the effect of CTE schools on educational attainment, specifically credit accumulation, and graduation?
- What is the effect of CTE schools on college-preparatory course taking in mathematics, science, and foreign language?

- What effect do CTE schools have on academic performance, specifically grade point average (GPA) and academic growth in mathematics and reading comprehension?

Our analysis focuses on the academic outcomes for students who were members of the School District of Philadelphia high school classes of 2003, 2004, and 2005. We restrict our focus to students who: 1) attended Philadelphia public schools for eighth grade; 2) applied to a career and technical high school for ninth grade; 3) were screened into the randomized lottery process for admission; and 4) attended a Philadelphia public high school during the following school year. Eighth grade students who applied to a career

and technical high school but were not promoted to ninth grade for the next school year were not included in this analysis. Students who transferred into the district in ninth grade or later were not included in the analysis. Likewise, students who left Philadelphia's public schools before beginning high school were excluded from the analysis, since their academic outcomes for high school could not be observed. Lastly, eighth grade students who applied to a CTE school but were screened out of the lottery pool, and therefore not a part of the randomized admissions process, are also excluded from these analyses.

The analyses presented in this paper rely entirely on administrative data sets obtained from the School District of Philadelphia. These data sets provide individual-level information about students: their course-taking, course grades, progress toward high school graduation, attendance, test scores, demographics, schools attended, and high school choice participation and outcomes. These data sets cover the period from school year 1998-1999 through school year 2004-2005 (the on-time graduation date of the class of 2005). For the class of 2003, we can track student graduation outcomes to six years past the entrance to high school; for the class of 2004, we follow students for five years after the start of ninth grade.

Challenges of Assessing the Effects of CTE Schools

National data indicate that, on average, CTE schools serve students who differ systematically from those who attend comprehensive high schools. For example, CTE schools are more than twice as likely as other schools to have moderate levels of students from low-income families, defined as 31% to 50% of the student body (52% for CTE schools versus approximately 20% of other schools). CTE schools also served higher percentages of students with an

Individualized Education Program. Further, CTE schools are larger on average than other high schools (Levesque et al., 2008). In any assessment of effects of CTE schools, these differences in the student populations served by the schools, as well as of the schools themselves, need to be taken into account.

Research on school choice systems have also shown that students who participate in school choice programs differ in important ways from those who do not participate, creating another possible bias for our study of students admitted to Philadelphia CTE schools. Often, students who apply to any school outside of their attendance zone have higher test scores, report card grades, and/or attendance than those who do not apply (Martinez, Godwin, Kemerer & Perna, 1995; Moore & Davenport, 1990). Students who submit applications often have parents who are more engaged in and informed about the school choice process, which can be complex in some cities (Moore & Davenport, 1990). As a result, CTE schools may serve a group of students whose parents are more involved and ambitious for their children, or at the very least, who have talked with their children about life after high school. Likewise, their parents are more likely to have completed more schooling and to have been more involved at the students' previous school (Furstenburg, Cook, Eccles, Elder, & Sameroff, 1999; Martinez et al., 1995). Further, students who apply to career and technical schools may have different occupational and academic interests from those who do not apply to such schools. It can therefore be difficult to assess how much of any effect of CTE schools is the result of CTE education itself, as opposed to the assembling of students who had the resources to negotiate the school choice process.

In social science, an ideal assessment of the effect of an intervention such as CTE education would use a random-assignment strategy, in which students who have

indicated an interest in CTE education are randomly assigned to experience either a CTE school or another type of school. Occasionally, this random assignment process is mimicked in so-called "natural experiments," the primary purpose of which may have been to distribute a relatively rare but sought-after good in an impartial manner. Such was the case with Philadelphia's CTE high schools in the late 1990s. During that time period, Philadelphia's CTE schools were substantially "oversubscribed," meaning that there were many more applicants than available seats at the schools. As a result, Philadelphia used a lottery to offer admission to its CTE schools. This natural experiment allows us to control for student interest in Career and Technical high schools as well as family or school support or student initiative that would lead the student to participate in the high school choice process in the first place. In this paper, we take advantage of this "natural experiment" in Philadelphia to assess the impact of CTE schools. A random assignment process provides greater assurance that any unobserved or unobservable differences between students who are accepted to CTE schools and those who are not are distributed randomly between the two groups. It is this random assignment process that gives this study its methodological strength. At the same time, it remains a case study of the Philadelphia school district, and the degree to which results can be extrapolated to other school districts depends on the overlapping similarities in contexts of the districts and CTE schooling within.

Comparison of Treatment and Control Groups

To assess whether the lotteries really appear to have been conducted randomly, we examined the predictors of being accepted to each of the schools for each of the cohorts through logistic regressions. If we were to see few or no statistically significant predictors of acceptance, then we would have confidence that a randomized lottery actually took place. In the main, the academic and attendance differences between those who were accepted and those who were not are not statistically significant. There are two sets of variables that are consistently significant predictors of acceptance. First, a student's race or ethnicity is a predictor for the class of 2003, where African American students had lower odds than Whites of being accepted to School A and School C, but twice the odds of Whites of being accepted to School B. These effects demonstrate that in most cases the lotteries are not completely random because of the need to achieve racial balance in these schools. The second set of variables that predicts acceptance is whether the student applied to other CTE schools and the ranking that was given to each CTE school. Applying to other CTE schools reduces the odds of being accepted to a given CTE school, since students could only be accepted to a single school. In addition, students who indicated that a CTE school was one of their top choices had higher odds of being admitted to the school than those who were more interested in another school.

In sum, the logistic regressions indicated that with the exception of race or ethnicity for some schools in some years, accepted and non-accepted students are comparable on key characteristics. Therefore, it is highly plausible that a genuine lottery was conducted; that is, a random assignment process actually occurred, without tinkering by principals or other district administrators. However, given their consistent effects on the odds of receiving an acceptance to a CTE school, we control for student race/ethnicity and the ranking the student gave the school on the application in our estimates of impact.

Treatment Crossover

Another post-randomization concern in comparing the treatment and control groups is the effect of treatment crossover. In addition to the Career and Technical high schools, there were numerous other public high schools in the city to which students could apply. Students could have been accepted to more than one high school, with acceptance contingent on the specific combination of schools to which they applied as well as their academic, attendance, and behavior histories. Students who were accepted to multiple high schools would have to make a decision about which offer of admission to accept. Even if they were accepted only to one high school, they still were faced with a decision of whether to accept that offer or attend their default neighborhood high school. The fact that the high school choice system in Philadelphia made *offers of admission to high schools* rather than *placements at high schools* means that there were many students who were, in research parlance, "assigned to the treatment" but did not experience that treatment. Rather, they attended their neighborhood high school, a special admissions school, or left the non-charter public system entirely. In addition, there were a few students for whom we have no record of their admission to a particular career and technical school but who appear on that school's rolls for ninth grade anyway. These students were assigned to the control group but managed to experience the treatment anyway.

Of the 8,131 students who were offered admissions to a CTE school through the lottery process during the time of this study, 3,497 (or 43%) did not attend a CTE school at all during high school, 718 students (9%) attended for only one year, 724 (9%) attended for two years, and 705 (9%) attended for three years. Some students dropped out; others returned to their neighborhood high schools, and only 2,487 (31%) of those who were

admitted actually attended a CTE school for all four years of high school. Further, 109 of the 7,495 students who lost the lottery process and were *not* offered admissions to a CTE school did in fact attend one. They may have managed to be assigned to a CTE school somehow, perhaps through a parent's direct intervention with the principal, or there may have been a few mistakes in the data files that we received from the district. In sum, the amount of total crossover demonstrates why it is important to consider in estimating the impact of CTE schools on student outcomes.

Estimates of Impact and Modeling Strategies

In order to account for the treatment crossover effects, we present two different estimates of the impact of the CTE schools. Our intent-to-treat (ITT) analysis estimates the overall impact of offering the "treatment" of CTE schools to students in the district. The local average treatment effect (LATE) estimates then adjust for the fact that not every accepted student chose to attend a CTE school. The ITT estimate answers the question: *what was the effect on key academic outcomes of offering the opportunity to attend a CTE high school?*. In this analysis, students who were offered a place at the school are considered to be the treatment group, *regardless of whether they actually attended the CTE school*. Students who participated in the randomized lottery process but were not admitted – who did not "win" the lottery – are considered to be the control group. The LATE estimate is derived similarly to the ITT estimate, but the resulting coefficients are then divided by the difference in treatment-receipt rates between the treatment and control group. The LATE estimates thus take into account the treatment crossover effect which may lower ITT estimate of CTE impacts. The LATE estimates are also equivalent to an instrumental-variables estimate. For both the

ITT/LATE estimates, we control for race/ethnicity and the ranking the student gave the school on the application. We control for these factors given the theoretical and empirical evidence presented above for their importance in determining admissions decisions.

We used two different modeling strategies to estimate CTE Intent-to-Treat effects. We use these two strategies for the following reason. Since the CTE schools used different screening criteria to shape their cohorts before conducting their lotteries, and since these criteria are unknown to us, it is important to compare outcomes for students who were accepted to the same lottery. Thus, since the class of 2003 had no screening criteria, and since the criteria may have been applied differently to the classes of 2004 and 2005, we compared outcomes for students accepted to a particular high school *only* to those students who applied but were not accepted to that school for the same cohort. This strategy ensured that we compare outcomes for students who are indeed comparable.

The first modeling strategy – a mixed model that includes both fixed and random effects—allows students to be represented in the data set multiple times. The number of times that students appear in the data set is equivalent to the number of CTE schools to which he or she applied. We used multilevel modeling (Raudenbush & Bryk, 2002; Seltzer, Choi, & Thum, 2003; Snijders & Bosker, 1999) with students nested within lotteries. Since students who were entered into the lottery at more than one CTE school are represented in the data set more than one time, we used robust standard errors to correct for the non-independence of some observations (White, 1982). Separate models were estimated for the three different cohorts. In essence, then, we found the CTE effect for each lottery and create an average across all CTE lotteries for a given cohort.

It is essential to note that this modeling strategy produces conservative estimates of the overall impact of CTE schools. This is because a student who applied to multiple CTE schools and attended one of them will be included as a "treatment" student once for the lottery to which he or she was accepted and as a "control" one or more times for other lotteries to which the student applied but was not accepted. The percentage of students who were rejected from specific CTE schools but who attended another CTE school ranges from 11%-37% across the various lotteries for each school and cohort. The potential for depressing any positive effects of CTE is particularly acute for the class of 2005, in which between approximately one-quarter and one-third of the rejected applicants enrolled at other CTE schools. (LATE estimates were also based upon this mixed model strategy.)

Given the potential of this modeling strategy to underestimate the overall effects of CTE schools, we produced a second set of fixed-effects estimates in which students are represented only once in the data set. The treatment variable is a dummy variable for whether the student was accepted to *any* CTE school. Instead of nesting students within lotteries, we included a set of four dummy variables (five variables for the class of 2005) indicating whether the student was included in a lottery for a specific school. This modeling strategy has the disadvantage of not being able to control for the ranking that a student gave a specific school on their application (which we know had an impact on a student's probability of being accepted, and potentially indicated more or less serious interest in CTE education) nor does it compare students to others who were not accepted to a *particular* school. It has the advantage, however, of not including in the control groups any students who attended CTE schools.

The equation we used for both the ITT and LATE mixed models is as follows. This equation is for continuous variables such as scores on standardized tests; for binary dependent variables, we used a multilevel logit model.

Level One

$$Y_{ij} = \beta_{0j} + \beta_{1j}(accepted\ to\ Lottery\ l\ in\ year\ y)_{ij} + \beta_{2j}(African\ American)_{ij} + \beta_{3j}(Asian)_{ij} + \beta_{4j}(Latino)_{ij} + \beta_{5jk}(other\ ethnicity)_{ij} + \beta_{6jk}(ranking\ given\ to\ school)_{ij} + r_{ij}$$

Level Two

$$\beta_{0j} = \gamma_{00j} + u_{0k}$$
$$\beta_{1j} = \gamma_{01j}$$
$$\beta_{2j} = \gamma_{02j}$$
$$\beta_{3j} = \gamma_{03j}$$
$$\beta_{4j} = \gamma_{04j}$$
$$\beta_{5j} = \gamma_{05j}$$
$$\beta_{6j} = \gamma_{06j}$$

The equation for the Intent-to-Treat fixed-effects model is as follows. Binary dependent variables were modeled with a logit model.

$$Y = \beta_0 + \beta_1(accepted) + \beta_2(White) + \beta_3(Asian) + \beta_4(Latino) + \beta_5\ (in\ School\ A\ lottery) + \beta_6(in\ School\ B\ lottery) + \beta_7(in\ School\ C\ lottery) + \beta_8(in\ School\ D\ lottery) + r$$

ITT Estimates of CTE School Impacts

Table 3 summarizes ITT and LATE estimates of CTE school impacts on key academic outcomes: graduation, GPA, academic growth, and college-preparatory course completion. For comparison, estimates from both a mixed model ITT and a fixed effects ITT model are presented. Each of these sets of estimates includes controls for student race/ethnicity and school ranking. In general, the estimates from the fixed-effects models are larger than those obtained from the mixed model. In addition, for the class of 2005, many of the fixed-effects estimates are statistically significant, while those from the mixed model are not. Finally, both the mixed model and fixed effects model estimates indicate that the class of 2005 did not perform as well as either the classes of 2003 or 2004, although many of the effects continued to be in favor of CTE schools. It is beyond the scope of this paper to explain why these differences existed across cohorts. The LATE estimates followed the same pattern and significance as the ITT estimates, but the impacts are of a larger magnitude as they take into account treatment crossover effects that may depress ITT estimates of impact.

Table 3 shows that the most consistent positive effects of the CTE schools are those related to educational attainment – in this case, graduation from high school. For both the classes of 2003 and 2004, estimates from both the mixed model and fixed-effect model indicate a positive effect of CTE schools. As per the ITT estimate for these two classes, students who were accepted to CTE schools had odds of graduating on time that were one-third higher than lottery students who applied to but were not accepted to a CTE school. For the LATE estimates, the odds of graduating on time are roughly double for those students who were accepted to CTE schools. For the class of 2005, the fixed-effect estimate indicates that students accepted to CTE schools had odds of graduating on time that were 20% higher than students who were not accepted. The estimate from the mixed model is not statistically significant for the class of 2005. The CTE school effect also is seen in the odds of graduation within five years of entering high school and, for the class of 2003, six year graduation. Each of the estimates for the class of 2003 places odds of five year graduation at least 30% higher for students accepted to CTE schools; for the class of 2004, the odds are at least 20% higher. For the class of 2003, the odds of graduation within six years were 30% higher for CTE applicants who were accepted.

Given the graduation advantage of CTE schools, it makes sense that the CTE treatment group earned more credits over the course of their high school careers. For the class of 2003, both mixed model and fixed-effects estimates indicate at least a two credit CTE advantage; for the class of 2004, the effect starts at approximately one credit. The CTE effect on credit accumulation for the class of 2005 is less than one credit, according to the fixed effects estimate; the estimates from the mixed models are not statistically significant. Not surprisingly, the CTE effect is positive for the number of CTE courses taken during high school. GPA effects of CTE schools are inconsistent, with positive effects for some cohorts and modeling strategies and negative effects for others. In all cases, the effects are small – less than one third of a GPA point. A reasonable conclusion is that, overall, there were no discernable effects of CTE schools on GPA. The same conclusion applies to academic growth in reading comprehension and mathematics. For some cohorts, the direction of the CTE effect is negative; for others, it is positive. With the exception of the mixed models for the class of 2004, none of the effects is statistically significant at the .05 level (although some of the mathematics estimates approach statistical significance).

Table 3

Estimated Intent-to-Treat (ITT) and Local Average Treatment Effect (LATE) Impacts of Acceptance to a CTE School on Academic Outcomes, Classes of 2003, 2004, and 2005.

	Class of 2003			Class of 2004			Class of 2005		
			Fixed Model			Fixed Model			Fixed Model
	ITT	LATE	ITT	ITT	LATE	ITT	ITT	LATE	ITT
On-time graduation	1.33*	1.97*	1.36*	1.36*	2.55*	1.31*	1.09	1.42	1.20*
Five-year graduation	1.30*	1.87*	1.33*	1.24*	1.90*	1.22*	+	+	+
Six-year graduation	1.31*	1.89*	1.36*	+	+	+	+	+	+
Total credits earned	2.16*	5.14*	2.52*	.91*	2.75*	1.16*	3.14	12.56	.83*
Number of CTE courses taken	.63*	1.50*	.84*	.12*	.37*	.63*	-.07	-.28	.79*
Total GPA	.13*	.32*	.11*	.09*	.27*	-.05	.02	.08	-.14*
Academic growth – mathematics	-.77	-1.83	-.82	1.16*	3.52*	.53	.77	3.08	-.14
Academic growth – reading	-.04	-.09	.06	.94*	2.85*	.32	.11	.44	-.61
Completed algebra 1, algebra 2, geometry	1.57*	2.94*	1.78*	1.39*	2.70*	1.76*	1.07	1.30	1.36*
Completed 2 years of a foreign language	1.28*	1.80*	1.29*	1.14	1.49	1.00	1.02	1.09	1.13
Completed chemistry and physics	1.09	1.22	1.00	.71*	.35*	.51*	.91	.67	.76*

*Statistical significance level of p<.05.
+Data not available to produce these calculations

The ITT estimates of CTE effects also are inconsistent with regard to completion of college-preparatory coursework. There are substantial positive CTE effects across cohorts and estimation methods for completion of a three-course sequence in

algebra 1, algebra 2, and geometry. The odds for CTE range from 36% greater to almost 200% greater. For the class of 2003, the CTE impact on completion of two or more years of a foreign language are statistically significant and substantial, with odds at least 25% higher. However, the classes of 2004 and 2005 do not share this advantage. Although the effects are mostly positive, they are small and not statistically significant. The effects for completion of chemistry and physics are genuinely mixed. For the class of 2003, there is no statistically significant difference between accepted and non-accepted students, but for the class of 2004, students accepted to CTE schools have lower odds of completing the two-course science sequence. The fixed effects model for the class of 2005 also indicates a CTE disadvantage.

To confirm that the ITT effects of CTE schools that we observed – particularly those that indicated a consistent CTE advantage (graduation, credit accumulation, completion of a college-preparatory mathematics sequence) – were not being driven by one or two schools, we compared mean outcomes for *accepted and non-accepted lottery students* for each school and each cohort.

While substantial differences between the applicant pools of the five CTE schools in terms of demographic backgrounds were noted, proportions of students eligible for the federal free/reduced lunch program, and prior academic achievement levels, comparisons indicated that for all outcomes except one (completion of science courses), the effects of CTE schools apply across the four schools (or five schools, depending on the cohort).

Beyond the impact of CTE schools on students' academic outcomes, another important story to emerge from the data analyses is that outcomes are not particularly good for any group of students. For each comparison and each cohort, the total GPA was less than a "C," on average. Mean attendance was in the low 80% range, at best – meaning that students, on average, missed the equivalent of about seven weeks of school each year. In terms of credits earned, the mean was below the number needed to graduate (23 credits), and none of the comparison or treatment groups had six-year graduation rates of even 70%. Table 4 shows the sample descriptive statistics for demographic variables and key outcome measures.

Table 4

Sample Statistics for Demographic Variables and Key Academic Outcomes.

Variable	Mean	Variable	Mean	SD
Female (%)	54	Five-year graduation (%)	60	
Overage (%)	15	Six-year graduation (%)	58	
Special education (%)	14	Completed algebra 1, algebra 2, geometry (%)	33	
ESL (%)	3	Completed 2 years of a foreign language (%)	75	
White (%)	13	Completed chemistry and physics (%)	19	
Asian (%)	5	Total credits earned	19.2	9.6
Hispanic (%)	11	Number of CTE courses taken	1.9	2.0
Black (%)	71	Total GPA	1.6	0.8
Other (%)	<1	Academic growth – mathematics	+1.2	12.6
On-time graduation (%)	54	Academic growth – reading	-0.2	12.0

Discussion

The analyses presented in this paper address scholarly and policy territory that is both old and new. On the one hand, there has been considerable research on the academic effects of taking career and technical education courses. The findings from these previous studies have been contradictory, in part because the research designs typically are hampered by selection bias. At the same time, there has been almost no research on academic outcomes associated with attending a career and technical school. Considering that almost 10% of American high school students attend high schools with primary and explicit missions to prepare students for careers – including careers that require additional postsecondary education – this study helps to fill a gap in current knowledge about outcomes associated with attending one of these so-called "CTE schools". Also considering the focus of policy and reform efforts of the past decade on raising high school graduation rates, any association between CTE schooling and stronger student outcomes may lead to calls for further investment and expansion in CTE based schools.

This study describes the CTE schools and their impact on academic outcomes for a single district (the School District of Philadelphia) and its specific context. The research is, in the end, a case study of the effects of CTE schools in a particular large-city school district. As with any case study, a full interpretation of the results must take into account how the city's social and educational context affects how CTE schools are supported and perceived by the community and district staff. While this paper does not present an exhaustive analysis of how parents and students view Philadelphia's CTE schools, the empirical data demonstrate that in Philadelphia, the Career and Technical high schools were highly sought after. Large percentages of eighth graders applied to at least one CTE school for high school. Further, CTE schools are not viewed by parents as providing only low-level skills. Interviews with parents of Philadelphia eighth graders who were going through the high school admissions process suggest that some parents perceive CTE schools to be a way to access college-preparatory courses while giving the student a set of skills to "fall back on" (Neild, 2005).

Further, while the CTE schools in Philadelphia were rather run-of-the-mill in terms of the occupational foci and curriculum, they were subject to school district efforts to increase college-preparatory course taking in all high schools. Thus, there were many opportunities for students at CTE schools to take college-preparatory mathematics, science, and foreign language. The high percentages of CTE students who earned credits in these courses supports the argument that CTE schools did not perform as a "dead end" school or a "school of last resort." In cities where parents and students perceive CTE schools as an undesirable option, or in school districts where CTE schools are treated as appropriate only for students who have no other skills, the effects of CTE schools could be quite different. One of the clear messages of this study, however, is that *it is not always or necessarily the case that CTE schools are associated with weaker academic outcomes for students.* In some situations – Philadelphia being one of them – academic outcomes for students who were given the opportunity to study at CTE schools may equal or exceed those of students left to attend the other schools in the district. That these impacts were observed in a research study that used randomized design strengthens the validity of this assertion.

It is beyond the scope of this paper to investigate the mechanisms that produce the CTE school impacts that we observe. However, we suggest several potential mechanisms that may contribute to the CTE

school impacts on educational attainment, credit accumulation, and course completion in mathematics and foreign language. Perhaps there is something powerful about CTE education, including the possibility that it helps students to see more clearly the connections between schooling and workplace success. Or, there may be nothing intrinsically important about CTE as a school focus; instead, the important factor may just be that the school had a focus, in contrast to neighborhood high schools, which try to be all things to all students. There may be peer effects associated with bringing together students who have the personal advantages and prior achievement, demonstrated by participating in school choice and being pre-screened into the lottery (for the classes of 2004 and 2005). Students may perceive CTE schools as being special and work to maintain their grades and behavior so as not to be "returned" to their neighborhood high schools for inadequate performance. These hypothesized mechanisms, which are not mutually exclusive, await further investigation with data that are more nuanced than the administrative records to which we have had access.

With regard to these hypotheses, it is important to note that career and technical education *per se* is only one of the hypothesized mechanisms. It would be a mistake to conclude that this research supports an approach to high school curriculum that emphasizes career and technical education over other curricular focuses. On the other hand, it would be equally mistaken to dismiss career and technical education schools as *necessarily* – in all educational contexts—reducing the probability that students will graduate from high school and earn credits in gate keeping courses needed for admission to and success in postsecondary education. The empirical evidence makes clear that CTE schools in Philadelphia were associated with considerable student advantage in terms of graduation and college preparatory course taking.

We conclude with a reminder that although this study has identified many positive effects for CTE schools, there is still considerable room for improvement of student academic outcomes – regardless of whether students attended CTE schools or other schools. Although a considerably higher percentage of students who were accepted to CTE schools graduated on time in comparison to those who were not accepted (62% versus 46%, for the class of 2005), it is deeply concerning that almost 40% of the students accepted to CTE schools did not graduate within four years of beginning high school. The graduation rates are very similar for students who actually attended CTE schools. Likewise, although there was a considerable CTE effect for successfully completing the algebra 1/algebra 2/geometry course sequence, almost 30% of those who were accepted to CTE schools for the class of 2005 did not earn an Algebra 1 credit. These findings remind us that, in an urban context where graduation from high school and college enrollment is not the norm, there is still a great deal of work to be done to keep students on the pathway to graduation and help them acquire the knowledge and skills they need to succeed in a 21st century economy.

References

Agodini, R. (2001). *Achievement effects of vocational and integrated studies.* Princeton, N.J.: Mathematica Policy Research, Inc.

Ainsworth, J. W., & Roscigno, V. J. (2005). Stratification, School-Work Linkages and Vocational Education. *Social Forces, 71*, 259–286.

Arum, R. (1998). Invested dollars or diverted dreams: The effect of resources on vocational students' educational

outcomes. *Sociology of Education, 71*(2), 130–151.

Bozick R., & Dalton, B. (2013). *Career and technical education and academic progress at the end of high school: Evidence from the education longitudinal study of 2002*. RTI International.

Cellini, S. R. (2006). Smoothing the transition to college? The effect of tech prep programs on educational attainment. *Economics of Education Review, 25*(4), 394–411.

Crain, R. L., Allen, A., Thaler, R., Sullivan, D., Zellman, G. L., Little, J. W., & Quigley, D. D. (1999). *The effects of academic career magnet education on high schools and their graduates.* Berkeley, CA: National Center for Research in Vocational Education.

Cullen, J., Jacob, B., & Levitt, S. (2000). *The impact of school choice on student outcomes: An analysis of the Chicago Public Schools.* National Bureau of Economic Research Working Paper 7888. Retrieved from www.nber.org/papers/w7888.

Dalton, B., Lauff, E., Henke, R., Alt, M., & Li, X. (2013). *From track to field: Trends in career and technical education across three decades.* RTI International.

Furstenberg, F., Cook, T., Eccles, J., Elder, G., & Sameroff, A. (1999). *Managing to make it: Urban families and adolescent success*. Chicago, IL: University of Chicago Press.

Garofano, A. & Sable, J. (2008). *Characteristics of the 100 largest public elementary and secondary school districts in the United States: 2004–05* (NCES 2008-335). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Hartmann, T. A., Reumann-Moore, R. J., Evans, S. A., Haxton, C., Maluk, H. P., & Neild, R. C. (2009). *Going small: Progress and challenges of Philadelphia's small high schools.* Philadelphia, PA: Research for Action.

Kaufmann, P., Bradby, D., & Teitelbaum, P. (2000). "*High Schools That Work" and whole school reform: Raising academic achievement of vocational completers through the reform of school practice.* Berkeley, CA: National Center for Research in Vocational Education.

Kemple, J. (2004). *Career academies: Impacts on labor market outcomes and educational attainment.* San Francisco, CA: Manpower Demonstration Research Corporation.

Kemple, J., & Snipes, J. (2000). *Career academies: Impacts on students' engagement and performance in high school.* San Francisco, CA: Manpower Demonstration Research Corporation.

Kemple, J., & Willner, C. (2004). *Career academies: Long-term impacts on labor market outcomes, educational attainment, and transitions to adulthood.* San Francisco, CA: Manpower Demonstration Research Corporation.

Levesque, K., Laird, J., Hensley, E., Choy, S. P., Cataldi, E. F., & Hudson, L. (2008). *Career and technical education in the United States: 1990 to 2005* (NCES 2008-035). Washington, D.C.: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Martinez, V.J., Godwin, R. K., Kemerer, F. R., & Perna, L. (1995). The consequences of school choice: Who leaves and who stays in the inner city. *Social Science Quarterly, 76*, 485-501.

Moore, D., & Davenport, S. (1990). School choice: The new school sorting machine. In W. Boyd & H. J. Walberg (Eds.), *Choice in Education: Potential and Problems* (pp. 187-223). Berkeley, CA: McCutchan Press.

National Assessment of Career and Technical Education. (2013). *Interim report*. Washington, D.C.: U.S. Department of Education, Office of Planning, Evaluation and Policy Development, Policy and Program Studies Service.

National Center for Education Statistics. (2008). *Schools and staffing survey (SASS), "Public school questionnaire," 2007–08*. Washington, D.C.; U.S. Department of Education.

Neild, R. C. (1999). Same difference: School choice and educational access in an urban district. Philadelphia, PA: University of Pennsylvania. *Dissertation Abstracts International*, *60,* 24-41.

Neild, R. C. (2005). Parent management of school choice in a large urban district. *Urban Education, 40*(3), 270-297.

Plank, S. B. (2001). A question of balance: CTE, academic courses, high school persistence, and student achievement. *Journal of Vocational Education Research, 26*(3), 279–327.

Plank, S., DeLuca, S., & Estacion, A. (2008). High school dropout and the role of career and technical education: A survival analysis of surviving high school. *Sociology of Education*, *81*(4), 345-370.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models* (2nd Ed.). Thousand Oaks, CA: Sage.

Seltzer, M., Choi, K., & Thum, Y. M. (2003). Examining relationships between where students start and how rapidly they progress: Implications for conducting analyses that help illuminate the distribution of achievement within schools. *Educational Evaluation and Policy Analysis, 25*(3), 263-286.

Snijders, T. A. B., & Bosker, R. J. (1999). *Multilevel analysis*. Thousand Oaks, CA: Sage Publications, Inc.

White, H. (1982). Maximum likelihood estimation of misspecified models. *Econometrica, 50*, 1-25.

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