How Much of A "Running Start" Do Dual Enrollment Programs Provide Students?

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INTRODUCTION

With more than 2 million students participating annually, dual-credit programs, which allow students to earn college credits while still enrolled in high school, have become the second most popular college preparatory program nationally after Advanced Placement. During the 2010–2011 school year, more than half of these students participated in programs that offered dual-credit courses on the campuses of postsecondary institutions (Thomas,

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Marken, Gray, Lewis, & Ralph, 2013). In the same year, 43% of public high schools nationwide offered students the opportunity to enroll in courses at a postsecondary institution. Because students earn college and high school credit simultaneously, these programs are seen as cost-effective way of increasing college readiness and college enrollment among high school students (An, 2013b; Bailey & Karp, 2013; State Board for Community and Technical Colleges, 2011). Yet, despite their popularity, there is relatively little empirical evidence of the impact of these programs on students' postsecondary enrollment choices or success in college. We use statewide data from Washington to investigate key postsecondary outcomes of students in Running Start, Washington's dual enrollment program.

We model the high school graduation and college enrollment decisions of dual enrollment participants using linear probability models that control for student demographic variables and academic achievement in high school. We find that dual enrollment students are more likely to earn an associate degree or enroll in college in the year following high school. However, we find no evidence that participants are more likely to enroll in college full-time and some evidence that participation raises enrollment at two-year colleges at the expense of enrollment in four-year colleges. We further find that dual enrollment students are more likely to drop out of high school or to complete high school by taking the GED. However, as with most prior studies of dual enrollment programs, we employ a research design, selection on observables, that supports a casual interpretation of our results only under strong assumptions about program participants.

While we are cautious about drawing causal inferences, the longitudinal dataset we employ in this study nonetheless allows us to make two important contributions to the literature on dual enrollment. First, our sample identifies students before their participation in dual enrollment programs. This allows us to control for measures of academic ability taken before participation in any dual enrollment programs and to capture outcomes for dual enrollment students who do not complete high school. We show that these restrictions influence our results, as dual enrollment students appear to have lower final grades than expected, perhaps due to stricter grading standards in college-level courses, and are less likely than non-participants to complete high school. Second, and most importantly, the data we analyze includes administrative records from the state higher education reporting system, as well as college enrollment outcomes derived from the National Student Clearinghouse. We therefore track postsecondary enrollment with much greater accuracy than has been possible in previous research and provide some of the first nearly complete descriptive evidence of postsecondary enrollment outcomes for dual enrollment students. Omitting postsecondary enrollments outside the public university system, which has been a common data limitation of prior

studies, generates very different results for dual enrollment students. We find that this omission increases our estimates of the college-going effects of dual enrollment programs by 8–9 percentage points. In particular, the current study illustrates the value of integrating secondary and postsecondary datasets for researching high school programs that influence college outcomes.

Dual enrollment and educational attainment: An overview

Although the design of dual enrollment programs varies somewhat from state to state, three common features of these programs are particularly salient to students' educational attainment. First, dual enrollment programs aim to increase the rigor of the high school curriculum, either by offering advanced courses at the high school or allowing students to enroll in courses on nearby college campuses. Second, they reduce the costs of college to students by providing tuition-free enrollment in courses that count for college credit or allowing students to earn college credit while in high school and thereby shortening the time required to complete a college degree. Finally, they tend to have institutional features that may incentivize enrollment in particular kinds of colleges by locating courses on a college campus or by negotiating transfer agreements for credits earned while participating.

To the extent that dual enrollment programs provide a more rigorous high school curriculum than would be otherwise available, participation would be expected to improve the preparedness of students for college and facilitate more informed decisions about college selection. Most studies find that students who take a more rigorous high school curriculum have higher educational attainment and earnings (Adelman, 1999, 2006; Allensworth, Nomi, Montgomery, & Lee, 2009; Attewell & Domina, 2008; Aughinbaugh, 2012; Dougherty, Mellor, & Jian, 2006; Long, Conger, & Iatarola, 2012; Morgan & Klaric, 2007; Rose & Betts, 2004; Speroni, 2011b), though these should not necessarily be interpreted as showing a causal relationship between high school curriculum and later outcomes, as there exists the possibility that unobserved factors are correlated with high school attendance and educational attainment.[1]

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[1] There is some quasi-experimental evidence on curriculum effects. Joensen and Nielsen (2009), for instance, examine a policy that increased the accessibility of advanced math courses and estimate an earnings premium of participation of about 20%, with the effect operating mainly through the increased likelihood of earning a postsecondary degree. Berger, Turk-Bicakci, Garet, Knudson, & Hoshen (2014) study early college high schools using admissions lottery results as an instrument and find that students in such high schools are about 3 percentage points more likely to attend college after high school completion.

The literature on the college dropout decision also suggests connections between the rigor of the high school curriculum and educational attainment. College students appear to respond to new information about their college-specific ability when deciding to continue investing in education (Arcidiacono, 2004; Stange, 2012; Stinebrickner & Stinebrickner, 2012). Dual enrollment programs may play a similar role for some students by providing them with low-cost information about their ability to succeed in college before making the more costly decision to enroll full-time. As Karp (2012) argues, this effect may come from the ability both to observe ("anticipatory socialization") and to imitate ("role rehearsal") college students and the academic and social behaviors required for postsecondary success. Participation in dual enrollment may therefore lead to better matches between student and college. Previous research has highlighted the important role of the quality of student-institutional matches in postsecondary persistence and completions (Arcidiacono, 2004; Light & Strayer, 2000). Consequently, dual enrollment policies may increase overall educational attainment by raising the graduation rate of those students who choose to enroll in college. For instance, An (2013a) finds that dual enrollment students who enroll in college are more likely to complete a degree than non-participants.

One of the touted benefits of dual enrollment programs is that they reduce the financial cost to students of attending college, either directly through tuition subsidies or indirectly by shortening the ultimate time to degree.[2] The dual enrollment program we study in Washington covers up to the $4,000 full-time tuition at state two-year colleges, which amounts to an aggregate annual tuition subsidy of about $40 million or $2,000 per student per year (Washington State Board of Community and Technical Colleges, 2010a, 2011). Additionally, by accumulating college credits while in high school, students may reduce the time it takes to complete a college degree, thereby reducing the opportunity costs of completing college.[3] By reducing the cost of obtaining a postsecondary degree, dual enrollment programs should unambiguously increase the likelihood that students enroll in some type of college after high school (Dynarski, 2003; Kane, 2007; van der Klaauw, 2002). However, as noted by Manski (1989), such policies might have a larger enrollment than completion effect if they induce more students with a higher probability of dropout to enroll.

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[2]In the 2010–2011 school year, 45% of high schools with academic-focused dual enrollment programs and 28% of career-oriented dual enrollment programs generally required parents to pay some out-of-pocket tuition costs (Thomas, Marken, Gray, Lewis, & Ralph, 2013).

[3]In the Washington State program, the average student takes 11 credits per quarter, or more than 60 credits if enrolled for both junior and senior years (State Board for Community and Technical Colleges, 2011).

Institutional features of dual enrollment programs may also influence the college enrollment decisions of participants. The Washington State program is housed at state community colleges. If college completion outcomes are uncertain, students who have nearly completed an associate degree may choose to enroll in a two-year college to take advantage of any sheepskin effects of the two-year degree (Light & Strayer, 2004). Moreover, the community colleges have transfer agreements with the in-state public, four-year universities as well as some private colleges that facilitate the transfer of credits and completion of major requirements. Dual enrollment participation may therefore lead some students to substitute preliminary coursework at a community college for preliminary coursework at a four-year institution. The empirical literature has reached divergent conclusions about how this could affect the probability of earning a four-year degree. On the one hand, this initial diversion could lead students to be better prepared for the rigor of four-year colleges and provide an opportunity to transfer to a higher quality college (Hilmer, 1997). On the other hand, several suggest that students with who first enroll in a two-year college with plans to transfer are less likely to complete a bachelor's degree than first-time enrollees at four-year colleges (Leigh & Gill, 2003; Long & Kurlaender, 2008; Rouse, 1995), although there is also some evidence that at least some of the "diversionary" effect of two-year colleges reflects differences in educational plans (Leigh & Gill, 2003). In summary, it appears from existing empirical work on community colleges that dual enrollment programs might be expected to increase postsecondary enrollment but that part of this increase may be offset by a reduction in the probability of students' completing bachelor's degrees conditional on enrollment. The overall effect on educational attainment is therefore unclear.

Review of the dual enrollment literature

Despite their popularity, there is relatively little evidence on the effects of dual enrollment programs on college attendance or completion. This reflects the difficulty in collecting information on student's high school academic history and college enrollment patterns. Until recently, statewide databases have not typically linked the academic records of high school students to postsecondary outcomes. Given this, the majority of previous studies have suffered from one of two missing data problems. First, several studies rely on selected samples of students where sample selection may be influenced by dual enrollment participation. Second, the datasets employed in most studies of college enrollment lack college enrollment data for a substantial portion of the sample.

The literature on the college completion effects of dual enrollment largely estimates effects for students who enroll in college, an outcome that may itself be influenced by participation. In a particularly careful analysis, An (2013a) analyzes data from the NELS:88 and finds that dual enrollment par-

ticipants who enroll in college are about 8 percentage points more likely to complete any college degree and 7 percentage points more likely to complete a bachelor's degree than non-participants. Other studies have examined the outcomes of students who enroll in particular postsecondary institutions and have found that students with prior dual enrollment participation generally earn higher grades and persist at greater rates (Allen & Dadgar, 2012; Karp, Calcagno, Hughes, Jeong, & Bailey, 2007).

While informative, estimates of program effects using selected samples represent the sum of two separate contrasts. The first is the causal effect of dual enrollment on college completion for students who participate in dual enrollment and register for college. This provides an estimate of the treatment effect for a subset of the all students that participate in dual enrollment programs. The second portion of the estimated effect is the difference in counterfactual completion rates for students who would attend college with dual enrollment participation and those who would attend college without participation.[4] This reflects the fact that dual enrollment affects the likelihood of completing college and the composition of those who enroll (Angrist, 2001). If dual enrollment programs uniformly increase college enrollment, this second effect may be negative, and the estimated effect could understate the causal effect of dual enrollment on college completion (Manski, 1989). On the other hand, if dual enrollment programs provide students with information about their ability to succeed in college and lead to better college-going decisions, estimated effects may actually overstate the causal college completion effect. Evidence on the college enrollment effect of dual enrollment programs may therefore be important for assessing the available long-term evidence on college completion.

Previous studies of the college transitions of dual enrollment students have estimated a wide range of effects on college enrollment. Karp et al. (2007) and Struhl and Vargas (2012) estimate that dual enrollment programs in Florida and Texas, respectively, have substantial effects on college enrollment. Karp et al., for instance, estimate that participation in Florida's dual enrollment program increases the probability of any college enrollment by

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[4]Let R represent college enrollment, C represent college completion, and D indicate dual enrollment participation. Further, let subscripts (0, 1) indicate the possibly counterfactual outcome that would be observed for students with D=0 and D=1, respectively. Then, if we assume conditional independence of (C, R) and D given covariates X, we can write the estimated effect among the college enrolled sample as $E[C|D =1, R =1, X] - E[C|D =0, R =1, X] = E[C_1 - C_0|D =1, R_1 =1, X] + (E[C_0|D=1, R_1 =1, X] - E[C_0|D =1, R_0 =1, X])$. The first term is the causal effect of interest, while the second is the result of selection into the sample. ruhf college attendance of 2.3Xonal Student Clearinghouse, a relative effect of f selection into the sample.decisions, estimate

16.8 percentage points and of university enrollment by 7.7 percentage points. Struhl and Vargas estimate an effect on the odds ratio of college attendance of 2.3.[5] Speroni (2011b) compares dual enrollment participation to AP participation and finds a relative effect of about 6 percent in favor of dual enrollment. Using a regression discontinuity design that exploits a minimum GPA eligibility requirement for some of Florida's dual enrollment programs, Speroni (2011a) finds no statistically significant effect of participation on either postsecondary enrollment or completion. The enrollment effects are imprecisely estimated, however, and 95% confidence intervals cover the effects found in the previous literature.

One limitation of many prior studies is the reliance on state data warehouses that omit records on private or out-of-state enrollments. The dataset used by Karp et al. (2007) includes college enrollment records only for students at in-state, public institutions. Similarly, the dataset used by Struhl and Vargas (2012) includes only enrollment in public or private institutions in Texas. These omissions may lead to substantial misclassification rates. Notably, Speroni's (2011a, 2011b) studies, which find smaller or null effects, rely on samples where data on in-state enrollments is combined with data from the National Student Clearinghouse. These omissions may lead to substantial classification error in the outcome variables of interest. For instance, Speroni (2011a) finds that in the dataset analyzed by Karp et al. (2007), 12% of all students are incorrectly classified as not attending college. Unlike with continuous dependent variables with classical measurement error, this form of classification error generally biases coefficient estimates. If the probability of misclassification is constant across observations, misclassification will tend to attenuate coefficient estimates (Hausman, Abrevaya, & Scott-Morton, 1998; Meyer & Mittag, 2013). However, in practice, the bias will depend on how the probability of misclassification varies with the sample covariates. We discuss this issue in more detail below. In our dataset, about 17% of students enroll in a private or out-of-state institution and we find that misclassifying these students as not attending college generates an upward bias in estimates of college enrollment effects of about 8–10 percentage points.

In this study, we are interested in the high school graduation and postsecondary enrollment patterns of dual enrollment students. Given the data limitations of prior studies, we are also particularly interested in how common classification errors in the college enrollment outcomes influence our results. In particular, we address the following research questions:

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[5]Struhl and Vargas (2012) do not report college enrollment rates, but if the enrollment rates of dual enrollment students in Texas are similar to those in Washington and Florida, the estimated odds ratios imply marginal effects in the range of approximately 0.13–0.19.

1. Do dual enrollment students graduate high school and attend college at higher rates than similar non-participants?
2. How do enrollment patterns differ by academic preparation and college intent?
3. How do missing data and sample selection influence estimates of differences in college enrollment rates?
4. In the next section, we discuss the Washington dual enrollment program and the data we use in this study. We then present an overview of the research methods and the results before concluding with discussions of how data limitations influence results, as well as the implications for policymakers.

Washington State's Running Start program

Washington's dual enrollment program, Running Start, started statewide in 1992 and has enrolled about 10% of the state's high school juniors and seniors in recent school years (Washington State Board of Community and Technical Colleges, 2010a, 2011). As with many other dual enrollment programs, Running Start allows juniors and seniors to take courses tuition-free at any of the state's 34 community colleges.[6] In Washington State, community colleges alone determine eligibility, which typically requires placement into a college-level English or mathematics course using a placement exam such as COMPASS or Accuplacer. Washington law specifically prohibits high schools from conditioning participation on administrator approval or high school academic record. This arrangement in Washington is far less restrictive than the norm for dual enrollment programs: 77% of schools nationwide require the permission of a counselor or administrator and 49% require a minimum cumulative grade point average (Thomas et al., 2013).[7]

School districts pay the community college 93% of the state basic education allotment for each full-time student participating in the program. The

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[6]Three universities also participate in the program, however we focus here on Running Start participation at the community college level because we have incomplete data on participants at four-year colleges, and it is difficult to distinguish the four-year college participants from students taking other transitional courses, such as College in the High School programs, in which students earn credit from courses taught on high school campuses by high school faculty members. More than 98% of students participate at a community or technical college. During the years we consider, 300–400 students participated each year at four-year colleges, while more than 16,000 participated each year at two-year colleges (Washington State Board of Community and Technical Colleges, 2010a, 2011).

[7]Since 2010, Running Start has required students to meet with a counselor to complete their registration. However, high schools may not condition participation on the approval of a counselor.

state estimates the total tuition subsidy cost $41.3 million for the 2009–2010 school year (Washington State Board of Community and Technical Colleges, 2011). As of 2010, colleges received approximately $4,500 per full-time equivalent Running Start student, which is estimated to represent only 60% of the cost of educating a two-year college student (Washington State Board of Community and Technical Colleges, 2010b, 2011).

Once students enroll in Running Start, they may take a combination of high school and college courses. Although all community colleges offer some distance education (mostly online), and many Running Start students take courses online, less than 1% of Running Start students take all their courses online.[8] Again, this is in marked contrast to the national norm for such programs: nationally, only 43% of schools with participants in academic-oriented dual enrollment programs have students attending school on a postsecondary campus (Thomas et al., 2013). Given the differences in eligibility requirements and the location of services, students in Washington's Running Start program appear to have much greater independence than students in similar programs in other states.

Although students may elect to attend college full-time while enrolled in Running Start, they must complete their district's graduation requirements to receive a high school diploma. School districts generally map specific courses taken at community colleges to particular state and district graduation requirements.[9] Consequently, more than half of Running Start students take credits amounting to full-time enrollment at a community college (Washington State Board of Community and Technical Colleges, 2011). In our sample, Running Start students earn an average of 41 credits, or slightly less than one academic year, while in high school, and 14% of participants actually earn an associate degree by high school graduation.

Upon graduation from high school, Running Start students have the same options for college enrollment as traditional high school graduates. Many, for instance, continue in the community college system and earn an associate degree. In our sample, in fact, about 30% of Running Start students continue at the *same* college immediately after graduation. Although they may have a substantial number of credits, the in-state public universities treat Running Start students as freshmen for admissions purposes. Alternatively, if they choose to complete an associate degree, Running Start students may apply to public four-year colleges as transfer students.

Given the myriad college pathways open to participants, Running Start students may have varied college plans at the time of enrollment. Using

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[8]10% of Running Start students take a majority of their courses online.

[9]Students who complete an associate degree before graduation can also apply for a high school completion certificate from their college.

data collected from all community college students during the registration process, we estimate that 24% of Running Start students plan to complete an associate degree and transfer to a four-year college, 41% state no plans for an associate degree but do plan to attend a four-year college, 8% plan to complete an associate degree only, and 27% have no specific plans for college.[10] Following high school, 73% of Running Start students enroll in any college and 36% enroll full-time in a four-year college.

Data

We use data on high school and college students from the Education Research and Data Center (ERDC) warehouse in Washington State. The ERDC data includes high school enrollment and standardized test records from the Washington Office of the Superintendent of Public Instruction (OSPI); community college attendance, transcript, and degree completion data from the Washington State Board of Community and Technical Colleges (SBCTC); and university attendance, transcript, and degree completion data from the Public Higher Education Enrollment System (PCHEES). Data on current and former Running Start participation are included in the SBCTC and PCHEES data systems. In addition to data on enrollments in public colleges in the state, the ERDC data includes information on enrollment in private and out-of-state colleges from the National Student Clearinghouse (NSC).

We focus on the cohort of high school students who first enrolled in ninth grade during the 2006–2007 school year and were still enrolled as juniors during the 2008–2009 school year. Our analysis dataset contains all students who enrolled in a standard high school during their freshman and sophomore years and continued their enrollment in the fall of their junior

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[10]We construct college enrollment intent using two questions asked of incoming community college students. The first asks about students' planned length of attendance at the community college and the second about the purpose of enrolling. We use the following classification:

AA and BA: Purpose is "Transfer to a four-year college" and planned attendance is "Long enough to complete a degree"

BA only: Purpose is "Transfer to a four-year college" and planned attendance is "One quarter", "Two quarters", "1 year", or "Up to 2 years, no degree planned"

AA only: Purpose is "Take courses related to current or future work", "High school diploma or GED certificate", "Explore career direction", or "Personal enrichment" and planned attendance is "Long enough to complete a degree"

No degree: Purpose is "Take courses related to current or future work", "High school diploma or GED certificate", "Explore career direction", or "Personal enrichment" and planned attendance is "One quarter", "Two quarters", "1 year", or "Up to 2 years, no degree planned."

It is important to note that the individual questions have not been validated for Running Start. Construction of the derived variables and the assumptions that underlie them are purely the work of the authors (David Prince, personal communication, June 19, 2014).

year.[11] As students have the option of enrolling in Running Start during the 11th and 12th grades, we study the outcomes for students participating in Running Start for school years 2008–2009 and 2009–2010. Our analytic sample includes 55,342 students, of whom 8,583 participated in Running Start. Table 1 provides mean student characteristics for students by their Running Start participation status.

We construct high school graduation measures using records from OSPI and SBCTC. For all high school completion variables, we include only outcomes that occur within four years of student's initial high school enrollment; that is, we consider completions that occur by the summer of 2010. Therefore, our outcomes properly measure on-time high school completion. The OSPI student reporting system explicitly codes students confirmed to have dropped out of school. Our dropout variable is defined using this code and may exclude students whose status is not confirmed by the reporting school. We obtain records on GED attainment from both OSPI, which records receipt of the GED as a possible graduation outcome, and SBCTC, which administers the test. Because Running Start students may obtain a high school diploma equivalent from their community college for either completion of the associate degree or of a credit-based high school equivalency program, we include any credit-based form of high school completion in our high school diploma measure. This definition is consistent with prior research that has found a distinction between credentials awarded for credit and those awarded for passing a test (Cameron & Heckman, 1993). When constructing the GED and dropout measures, we exclude students who otherwise obtain a valid high school diploma.

We obtained measures of student postsecondary enrollment from the SBCTC, PCHEES, and NSC databases. For the in-state public institutions, we derive college enrollment based on whether students register for a positive number of credits during the fall term of 2011 (the first term after scheduled graduation). Similarly, for students in the NSC database, we define college enrollment using the enrollment status reported by the NSC. We additionally consider whether students are enrolled full-time in college. For the in-state

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[11]In the cohort we study, 68,238 students met this enrollment condition. For the analysis, we only used students with complete cases for all control variables rather than imputing missing values. We therefore excluded students who did not complete the state testing or did not have sophomore year GPA data. To avoid possible endogeneity of test scores with Running Start participation, we also dropped students who had not completed the testing requirements in 10th grade. We also excluded special education schools, private school and home school students who enroll part-time in a public high school, and students who could not be linked to a high school. We dropped 640 students linked to non-standard schools and 12,256 students with missing data. Thus, our final sample represents 81% of eligible juniors.

TABLE 1
SUMMARY STATISTICS

	RS Students		Non-RS Students		All Students	
	Mean	SD	Mean	SD	Mean	SD
Student outcomes:						
HS Dropout	0.02	(0.15)	0.03	(0.18)	0.03	(0.18)
GED	0.01	(0.12)	0.02	(0.15)	0.02	(0.14)
HS Diploma	0.93	(0.26)	0.88	(0.32)	0.89	(0.31)
Earns associate degree	0.14	(0.35)	0.00	(0.00)	0.02	(0.15)
Any college enrollment	0.73	(0.44)	0.56	(0.50)	0.59	(0.49)
Any full-time college enrollment	0.59	(0.49)	0.48	(0.50)	0.50	(0.50)
Any college enrollment (inc. AA)	0.75	(0.43)	0.56	(0.50)	0.59	(0.49)
Any full-time college enrollment (inc. AA)	0.63	(0.48)	0.48	(0.50)	0.50	(0.50)
Full-time four-year college enrollment	0.36	(0.48)	0.31	(0.46)	0.32	(0.47)
Running Start participant, 11th grade	0.65	(0.48)	0.00	(0.00)	0.10	(0.30)
Running Start participant, 12th grade	0.85	(0.35)	0.00	(0.00)	0.13	(0.34)
Total Running Start credits earned	40.79	(30.20)	0.00	(0.00)	6.33	(18.96)
College intent: AA + BA	0.24	(0.42)	0.00	(0.00)	0.04	(0.19)
College intent: BA only	0.41	(0.49)	0.00	(0.00)	0.06	(0.24)
College intent: AA only	0.08	(0.27)	0.00	(0.00)	0.01	(0.11)
College intent: no degree	0.27	(0.45)	0.00	(0.00)	0.04	(0.20)
Student characteristics:						
Student gender: Female	0.41	(0.49)	0.52	(0.50)	0.50	(0.50)
Student race: Asian	0.11	(0.31)	0.08	(0.28)	0.09	(0.28)
Student race: Black	0.03	(0.17)	0.04	(0.20)	0.04	(0.20)
Student race: Hispanic	0.05	(0.22)	0.11	(0.31)	0.10	(0.30)
10th grade GPA	3.23	(0.62)	2.80	(0.84)	2.86	(0.82)
10th grade math WASL	0.45	(0.80)	-0.08	(1.01)	-0.00	(1.00)
10th grade reading WASL	0.41	(0.89)	-0.07	(1.00)	-0.00	(1.00)

	(1)		(2)		(3)	
10th grade writing WASL	0.37	(0.71)	-0.07	(1.03)	-0.00	(1.00)
FRL Status, 10th grade	0.13	(0.34)	0.22	(0.41)	0.20	(0.40)
Bilingual Status, 10th grade	0.01	(0.09)	0.03	(0.18)	0.03	(0.17)
Primary language is not English	0.09	(0.29)	0.12	(0.33)	0.12	(0.32)
Title I targeted assistance	0.05	(0.21)	0.09	(0.28)	0.08	(0.27)
Gifted education	0.04	(0.19)	0.03	(0.17)	0.03	(0.17)
Number of AP courses taken in grade 9–10	0.12	(0.36)	0.08	(0.30)	0.08	(0.31)
Migrant student	0.00	(0.06)	0.02	(0.13)	0.01	(0.12)
Unexcused absences	1.68	(5.87)	1.88	(6.38)	1.85	(6.30)
School characteristics:						
City: large	0.05	(0.22)	0.03	(0.18)	0.03	(0.18)
City: other	0.21	(0.41)	0.23	(0.42)	0.22	(0.42)
Suburb: large city	0.39	(0.49)	0.35	(0.48)	0.36	(0.48)
Town	0.11	(0.31)	0.12	(0.33)	0.12	(0.33)
Rural	0.14	(0.35)	0.16	(0.37)	0.16	(0.36)
Distance to college	7.73	(10.44)	8.87	(11.99)	8.69	(11.77)
N	8,583		46,759		55,342	

schools, we define full-time enrollment as attempting at least 12 credits for institutions on the quarter system and 10 credits for institutions on the semester system. As Running Start students may earn an associate degree during high school, the measures of college enrollment we use in our regressions include students who have enrolled in a two-year or four-year college or have completed an associate degree. We additionally identify students whose initial enrollment is in a four-year college following high school graduation.

We obtain pre-treatment student academic achievement and program participation information from OSPI enrollment records. We measure all student characteristics at the end of the sophomore year to avoid controlling for factors, such as grades, special education status, or free or reduced price lunch eligibility, which may be endogenous to Running Start participation. All tenth graders in the state take a standardized exam in reading, mathematics, and writing that we use in this analysis. Data on student grades, demographics, and program participation are also available from OSPI.

As is apparent from Table 1, Running Start students are more likely to attend college after graduation than non-participants. Seventy-three percent of Running Start students attend any college in the year after they graduate and 59% do so full-time. Both are far higher than the corresponding statewide means of 59% and 50%. However, Running Start students also have substantially better academic high school performance records than the overall population of high school students. They score about 0.4 standard deviations higher on the tenth grade standardized tests than the sample average and they have an average tenth grade GPA (3.23) that is nearly 0.5 points higher than the state average (2.86). They are also less likely to participate in special education, bilingual education, Title I, and/or the federal free and reduced price lunch program. Turning to the school level variables, we find that Running Start students are more likely to attend a school in Seattle (large city) or one of its suburbs. Running Start students are slightly less likely to come from districts in all other locations. However, community colleges are fairly well distributed across the state and the average distance between students and a Running Start program is only about one mile less for Running Start participants than non-participants. Accordingly, Running Start students are found in most schools across the state. About 15% of schools have no Running Start students in our sample and the interquartile range of school-level participation is 11 percentage points.

Dual enrollment, high school completion, and college attendance

Methods

We are concerned with estimation of the effect of Running Start participation on the probability of high school completion and college enrollment. As with much of the previous research on dual enrollment, we employ a selection on observables design to estimate the effects of participation.[12] That is, we estimate

$$Y_i = X_i\beta + \delta RS_i + \epsilon_i \tag{1},$$

where Y denotes high school completion or college enrollment, X denotes the vector of observed student covariates, and RS denotes participation in Running Start. We begin by estimating linear probability models that condition on a number of student characteristics that may influence postsecondary enrollment decisions. These include a cubic polynomial in sophomore grade point average and test scores in mathematics, reading, and writing from a state standardized test administered at the end of tenth grade, student gender, ethnicity, free and reduced price lunch status, student learning disability status, participation in a bilingual education program, an indicator for a primary language other than English, participation in a targeted Title I program, participation in gifted and talented classes, AP classes, migrant status, and unexcused absences. All student controls are measured during the student's tenth grade year before eligibility for Running Start. There is a debate about whether propensity score matching estimators provide better estimates of treatment effects in studies that rely on selection on observables designs (Dehejia & Wahba, 2002; Smith & Todd, 2005). Rather than rely on observable school characteristics in a propensity score matching framework, we estimate models with school fixed effects to allow some dependence of student outcomes on unobserved school-level factors, such as curricular rigor or college counseling, that may be associated with both dual enrollment participation and students' postsecondary outcomes. As there is evidence that attendance at individual high schools has causal effects on students' educational attainment (Booker, Sass, Gill, & Zimmer, 2011; Deming, Hastings, Kane, & Staiger, 2014), this approach allows us to control for some of the potential endogeneity between dual enrollment participation and student postsecondary outcomes. The treatment effect δ is therefore identified only under the assumption that unobserved student-level factors associated with

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[12]Speroni (2011a), which uses a regression discontinuity design, is an exception.

high school completion and college enrollment, ϵ_i, are uncorrelated with Running Start participation. This requires that students participating in a college preparatory program have similar college plans as observationally similar non-participants, an assumption that is unlikely to hold. We return to the plausibility of this assumption below.

The outcomes we consider are limited to short-term measures of educational attainment. In particular, we lack data on overall educational attainment. As discussed above, there are several reasons to believe that effects on initial enrollment and educational attainment will differ. Participation in dual enrollment programs may increase the likelihood of college graduation either directly by better preparing students for college-level courses or indirectly by inducing students with a greater likelihood of college completion to enroll. An (2013a, b) provides some evidence for this view. Moreover, dual enrollment programs that are located on community college campuses may encourage students to complete an associate degree at a two-year college before moving to a four-year institution. As noted above, among Running Start students in our dataset, 30% continue enrollment in the same college in the quarter after graduation. Therefore, shot-term measures of enrollment in four-year colleges may understate the long-term effects of such programs on educational attainment. Conversely, the educational subsidy effects of dual enrollment may encourage more marginal students to enroll in college. Nevertheless, prior research has relied mostly on samples with substantial measurement error in the postsecondary enrollment variables. We therefore provide some of the first evidence of such effects from a sample taken before participation and that includes a measure of postsecondary enrollment with little measurement error.

Results

We report the OLS results in Panel A of Table 2. Compared to similar students, Running Start participants are less likely to earn a traditional high school diploma and more likely to drop out of school. Specifically, the point estimates suggest that Running Start students are 2.3 percentage points less likely to earn a credit-based diploma, 1.1 percentage points more likely to drop out of school and 0.4 percentage points more likely to earn a GED. All estimated coefficients are statistically significant at the 1% level. These findings may seem counterintuitive, but there are several potential explanations.

First, Running Start students may view an interim high school diploma as unnecessary given the possibility of earning a two-year college credential. Some Running Start participants may therefore continue their enrollment in community college without completing a high school degree. Among the Running Start students who fail to complete an on-time high school diploma, 15% are still enrolled in the college in which they participated in Running Start in the year after their scheduled graduation. In order to capture this

TABLE 2
RUNNING START PARTICIPATION, HIGH SCHOOL COMPLETION, AND COLLEGE ENROLLMENT

	High School Completion			College Enrollment			
	Dropout	GED	Diploma	Any College	Full-time College	Full-time Four-year	No dip, no college
Panel A: Average Running Start Effects							
Running Start	0.011***	0.004***	-0.023***	0.054***	0.004	-0.091***	0.011***
	(0.002)	(0.001)	(0.003)	(0.006)	(0.007)	(0.006)	(0.003)
N	55342	55342	55342	55342	55342	55342	55342
Panel B: Running Start Effects by Academic Achievement							
Running Start, Q1 index	0.046**	0.042**	-0.049*	0.078***	0.026	-0.021*	0.016
	(0.021)	(0.016)	(0.026)	(0.025)	(0.023)	(0.011)	(0.023)
Running Start, Q2 index	0.022***	0.004	-0.058***	0.123***	0.064***	-0.014	0.032***
	(0.007)	(0.005)	(0.012)	(0.016)	(0.017)	(0.010)	(0.010)
Running Start, Q3 index	0.010***	0.003	-0.026***	0.066***	-0.009	-0.072***	0.015***
	(0.003)	(0.003)	(0.007)	(0.013)	(0.014)	(0.011)	(0.006)
Running Start, Q4 index	0.009***	0.002	-0.014***	0.023**	-0.039***	-0.140***	0.004
	(0.003)	(0.002)	(0.005)	(0.009)	(0.011)	(0.012)	(0.004)
Running Start, Q5 index	0.000	0.001	-0.005	0.032***	0.016	-0.115***	0.001
	(0.001)	(0.001)	(0.003)	(0.008)	(0.010)	(0.013)	(0.003)
N	55342	55342	55342	55342	55342	55342	55342
Panel C: Running Start Effects by Academic Intent							
Running Start, AA + BA	0.010***	0.003	-0.025***	0.083***	0.027**	-0.135***	0.010**
	(0.003)	(0.003)	(0.006)	(0.010)	(0.011)	(0.012)	(0.004)
Running Start, BA only	0.009***	0.004**	-0.020***	0.069***	0.022**	-0.060***	0.009**
	(0.002)	(0.002)	(0.004)	(0.008)	(0.010)	(0.009)	(0.004)

Table 2, cont.

	High School Completion			College Enrollment			
	Dropout	GED	Diploma	Any College	Full-time College	Full-time Four-year	No dip., no college
Running Start, AA only	0.027***	0.006	-0.048***	0.039**	-0.029	-0.187***	0.030***
	(0.008)	(0.005)	(0.013)	(0.018)	(0.020)	(0.017)	(0.010)
Running Start, no degree	0.009***	0.006**	-0.019***	0.010	-0.034***	-0.072***	0.010*
	(0.003)	(0.003)	(0.006)	(0.010)	(0.011)	(0.009)	(0.005)
N	55342	55342	55342	55342	55342	55342	55342

Notes: All regressions include the following variables: indicators for student sex, race, FRL, migrant status, whether English is the primary language, and 10th grade participation in targeted assistance (Title I) programs, bilingual education, gifted education, special education services, number of 9th and 10th grade Advanced Placement classes, and 10th grade GPA, unexcused absences, and standardized test scores in math, language arts, and writing. Regressions additionally include school fixed effects. Academic index is a weighted average of GPA and test scores where the weights are determined by a regression of college enrollment on the academic achievement variables using the non-Running Start sample. The academic intent variables are described in the text. Standard errors clustered by school in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

possibility, we estimate the effect of Running Start participation on the probability that a student neither completes an on-time diploma nor enrolls in college. We find that Running Start students are 1.1 percentage points more likely to have done so. That is, apart from the increased risk of dropping out of school, it appears that Running Start students are more likely to either delay graduation or substitute the associate degree for a formal high school credential.

Second, the relatively inclusive eligibility requirements of Running Start may attract a disproportionate share of non-traditional high school students who would be unlikely to complete a high school degree in the absence of the program.[13] If differences in the propensity to graduate high school are not captured by our measures of academic achievement, then the dropout effects may partially reflect selection into Running Start. On the other hand, even if the coefficients are unbiased, the eligibility rules may permit weaker students who may not benefit from college-level courses to participate in Running Start. We explore the latter possibility by analyzing the heterogeneity in Running Start effects by academic preparation. In Panel B, we estimate models that interact the Running Start indicator with a measure of academic achievement. To create the index, we regress the college enrollment indicator on tenth grade GPA and standardized test scores for students who do not enroll in Running Start and generate quintiles of the predicted values for each observation in the sample. The index is therefore a weighted mean of students' academic achievement variables, where the weights reflect their importance for predicting college attendance. When we disaggregate the Running Start effect in this way, we find that the high school graduation results are concentrated among students with low predicted probabilities of college enrollment. Students in the bottom quintile of academic preparation who participate in Running Start are 4.6 percentage points more likely to drop out and 4.2 percentage points more likely to earn a GED than similarly prepared non-participants. Similarly, we estimate that Running Start students in the bottom quintile are 4.9 percentage points less likely to earn a high school diploma, which is marginally statistically significant, and students in the second quintile are 5.8 percentage points less likely, which is statistically significant. We estimate statistically significant and negative graduation contrasts for the next two quintiles that are substantially smaller and find no difference in graduation rates for the most prepared Running Start students.

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[13]As we discussed earlier, Running Start does not condition participation on the approval of high school officials or have a statewide GPA requirement, although a few individual community colleges do. By contrast, 77% of schools with dual credit programs nationwide require administrator approval and 49% have minimum GPA requirements (Thomas et al., 2013).

Taken together, the results suggest that Running Start students are more likely to drop out of high school, but that estimates of on-time graduation effects may overstate the tendency for participants to fail to earn a secondary or postsecondary credential. Specifically, when we include college enrollees in the high school completion category, only about half of the negative completion difference remains.

In contrast to the negative high school completion findings, Running Start students are more likely to attend college or have earned a degree by the first term after graduation: Running Start students are 5.4 percentage points more likely to either attend any college or have already earned an associate degree, but they are no more likely to have either earned a degree by the fall term after high school or to attend college full-time. Furthermore, Running Start students are 9.1 percentage points *less* likely than similar non-participants to attend a four-year university full-time.[14] In results not shown, we find that the negative effect on four-year enrollment is strongest for students who earn nearly, but not quite, enough credits through Running Start to obtain an associate degree. Depending on the rate at which these students transfer to four-year colleges, some of the negative effect on four-year college enrollment may be temporary.

When we interact the Running Start indicator with measures of students' college preparation, we find that lower-performing students appear to gain the most from participation, which is consistent with previous studies of dual enrollment (Karp et al., 2007; Speroni, 2011b). Dual enrollment students in the bottom three quintiles of the academic achievement index distribution enroll in college at rates that exceed non-participants by 6 percentage points, while we observe small, but positive, differences for the top two quintiles. Similarly, we only observe positive full-time enrollment differences for students in the second quintile, whereas we estimate null or negative differences for all other participants. Finally, the estimates of the diversion effect of Running Start are small and either marginally or not statistically significant for the least prepared students.

Our identification strategy assumes that a limited set of academic and financial information sufficiently control for differences in educational attainment between Running Start and non-Running Start students. However,

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[14]Many dual enrollment programs include a heavy vocational component. Readers may be concerned that the college enrollment effects reflect students leaving school for the workplace after completing some amount of explicitly vocational training. We tested this possibility by excluding all students who took any vocational courses during their enrollment in Running Start and re-estimating all of our models. Despite the fact that about 41% of Running Start students in our sample take at least one vocational course, our results in these models are remarkably similar.

as noted above, students may select into Running Start based on financial and academic factors that are unobserved. Because dual enrollment programs offer very clear benefits to students who intend to enroll in college after high school, we might expect estimation strategies that assume selection on observables to overstate the true effect of these programs on the probability of college enrollment. On the other hand, the literature on college dropouts suggests that the informational benefit of dual enrollment programs may be greatest for students with the most uncertainty about their ability to succeed in college (Stange, 2012). If this is the case, students who choose to participate may be otherwise less likely to attend and persist in college than observationally similar students. Similarly, estimated program effects that control only for student background may overstate the diversionary effect of dual enrollment programs. Because students can make considerable progress toward an associate degree while in high school, dual enrollment students may at baseline be more likely to plan to initially enroll in a two-year college.

We present estimates of the Running Start indicator interacted with pre-participation college plans in Panel C. In column (4), we only find higher rates of college enrollment for students who indicate that they plan to complete a college degree. Students who state no plan to complete a college degree are no more likely than similar students to enroll in college and less likely to do so full-time. In column (6), we find that the four-year enrollment differences of Running Start are largest for students who indicate intent to complete an associate degree. While we estimate that students who plan to complete an associate degree before transferring are 13.6 percentage points less likely to enroll in a four-year institution, we find a difference of only -6.1 percentage points for students planning to enroll directly in a four-year institution. We interpret this as suggestive that selection into Running Start explains at least some of the estimated treatment effects. However, we note that this test must be taken with some caution. Running Start may increase educational attainment by increasing enrollment rates of students who consider themselves college bound rather than by increasing the college attendance rates of students who would otherwise not consider college. Similarly, Running Start students who declare their intention to earn an associate degree might have enrolled in a four-year college in the program's absence. Nonetheless, we do find some evidence that outcomes are correlated with college plans for Running Start students.

While the findings in Table 2 suggest that Running Start may shift some of the initial college enrollment toward two-year colleges, the results may not generalize to overall educational attainment. Among the 2011 graduating classes at Washington public universities, 40% of students had transferred from two-year colleges (Washington State Board for Community and Technical Colleges, 2013). Therefore, it is likely that some of these students

will eventually transfer to four-year colleges. An (2013a) provides some support for this view, suggesting that dual enrollment students who enroll in any college are more likely to complete a bachelor's degree than similar non-participants. Hence, these results should be interpreted as a short-run effect and are not necessarily indicative of overall educational attainment.

Nonetheless, our results suggest something of a paradox for the benefits of dual enrollment programs. If our estimates represent a causal relationship, then we find that participation in Running Start has both relatively large college enrollment effects and relatively large high school dropout effects for students on the margin of college attendance. Moreover, the effect on high school non-completion persists even when we count students enrolled in community colleges as having obtained a high school credential. These findings suggest that policymakers considering eligibility policies for dual enrollment programs may need to balance increased access to college against the costs to students of failing to complete a high school degree.

THE ROLE OF MISSING DATA IN ASSESSING DUAL ENROLLMENT PROGRAMS

Our estimates of differences in college enrollment rates by dual enrollment participation are substantially smaller than those found in previous studies of statewide programs. While Karp et al. (2007) and Struhl and Vargas (2012) find college enrollment effects of participation in dual enrollment programs of about 15-20 percentage points, we find effects of only about 5 percentage points. One key difference between our study and these previous studies is that we have a measure of college attendance that includes enrollment at private or out-of-state institutions. We therefore consider the role that this data plays in our analysis.

The effect of misclassifying college attendance depends on the relationship between dual enrollment participation and the included covariates. In dual enrollment studies, the misclassification almost always consists of students who actually attend college but for whom enrollment records are missing. Typically, college students lack enrollment records because they attend private or out-of-state schools that are not included in state administrative databases. Of the several studies that consider the college attendance effects of dual enrollment described earlier, only Speroni (2011a, 2011b) include data obtained from the National Student Clearinghouse on college enrollments outside the public university system. If the rate of enrollment in such institutions is equal across participants and non-participants, conditional on other covariates, then the estimated effects of dual enrollment participation will tend to be attenuated toward zero (Hausman et al., 1998; Meyer & Mittag, 2013). The degree of attenuation will be approximately equal to the percent of students attending non-covered colleges, which we estimate

at 17% in our dataset and is 10–15% in states considered in several existing studies (Speroni, 2011b; Struhl & Vargas, 2012).

Empirically, however, we observe that Running Start students are more likely to attend in-state public colleges than other similar students. This is not surprising given that they have already begun enrollment in a public college, and the state public universities have transfer agreements with community colleges that allow transferred credits to satisfy specific core curriculum and major requirements (Washington Council for High School-College Relations, 2014). Thus, it is likely that, without data on enrollments in private colleges or out-of-state public colleges, estimates of dual enrollment effects are biased upward.

While our measure of college enrollment may be more complete than those used in previous studies, the NSC data has some well-known limitations (Dynarski et al., 2013).[15] We therefore begin by assessing the remaining measurement error in our data. In order to estimate the misclassification bias, we first need estimates of the probability of misclassification and the expected values of the covariates given misclassification (Meyer & Mittag, 2013). We describe the estimation procedure more fully in Appendix A, but briefly describe the assumptions we make. There are four sources of missing data in our analytical dataset. First, students who do not graduate high school are typically not submitted to NSC for matching. Nonetheless, some students who do not graduate high school do attend postsecondary institutions, usually at community colleges. We assume that students who do not complete high school do not attend colleges outside the Washington public college system. Second, approximately 3.5% of high school graduates were not submitted to NSC for matching. We assume that these students attend college outside the Washington public college system at similar rates as submitted students. Third, students may block the release of their records by NSC. Fourth, not all postsecondary institutions are covered by NSC. For these last two limitations, we assume that blocking and institutional coverage are independent of inclusion in our dataset conditional on attendance at a private or out-of-state college.

Using these assumptions, we estimate that a small percentage of students are misclassified as not attending college. Across all observations, we estimate that 2% are classified as not attending college but actually enroll, while we

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[15]In particular, the NSC does not obtain records from all post-secondary institutions and some students block the release of their attendance records. In addition to these standard limitations, we also lack enrollment records for those students who fail to complete a high school degree, a small number of whom do enroll in postsecondary institutions. The effect of this latter category is likely to be small, particularly since they seem to enroll predominantly in public two-year institutions, which have open enrollment policies.

estimate that 1.7% are not properly classified as attending college full-time or attending a four-year institution. Following the method of Meyer and Mittag (2013), we estimate that these omissions cause an upward bias in all of our estimates. In Table 3, we display the bias estimates for each of our college enrollment outcomes. We estimate an upward bias of 1.1 percentage points for the college enrollment outcome, 0.8 percentage points for the full-time college enrollment outcome, and 0.6 percentage points for the full-time, four-year college enrollment outcome. While the first two estimates are large relative to the coefficient estimates, they do not substantially change the college enrollment results.

We now compare our results to those of previous studies by omitting in-state private and out-of-state college enrollments from our college attendance measures. In Table 3, we repeat the baseline regressions in Table 2 using only enrollments in state public two- and four-year colleges as our outcomes. Although the majority of college students are correctly classified, the omission of private and out-of-state enrollments substantially alters our estimates of the differences in college enrollment patterns between Running Start students and non-participants. Excluding private and out-of-state enrollments, the estimated coefficient on the Running Start indicator for any college enrollment increases from 0.054 in column (1) to 0.145 in column (2). We see similar increases in the coefficients when the outcome is full-time or four-year enrollment, which increase from 0.004 to 0.080 and from -0.091 to -0.057, respectively.

In our sample, 72% of first-time college students enroll in a Washington State public college. It should be noted that the coverage rate for in-state publics is somewhat smaller than those reported in other studies, which typically have coverage of about 80% of college enrollments. We therefore provide estimates of the relationship between the misclassification bias and the probability of misreporting that supports the bias estimates in Table 3. The external validity of this assessment relies on the assumption that the average characteristics of students with missing college enrollment outcomes are similar in our data to those used in other states. Given the differences in eligibility requirements between Running Start and dual enrollment programs in other states, it is unclear how these results will translate to different contexts. However, there is reason to think that estimates based on the Washington data are actually conservative estimates of the biases in other contexts. If dual enrollment students in other states disproportionately enroll in public, in-state colleges to enroll in the college in which they take courses or to take advantage of transfer agreements, as they appear to do in Washington, then in other states with more selective programs there may be a greater discrepancy between the in-state public and private or out-of-state enrollment rates between participants and non-participants who are

TABLE 3

SENSITIVITY OF RESULTS TO MISSING DATA AND SAMPLE SELECTION

			Other Data Scenarios		
Dependent variable	Baseline	Est. Bias	(1)	(2)	(3)
Any college enrollment or AA deg.	0.054***	0.011	0.145***	0.059***	0.077***
	(0.006)		(0.007)	(0.006)	(0.007)
Full-time college enrollment or degree	0.004	0.008	0.080***	0.009	0.032***
	(0.007)		(0.007)	(0.007)	(0.007)
Full-time four year college enrollment	-0.091***	0.006	-0.057***	-0.091***	-0.063***
	(0.006)		(0.006)	(0.007)	(0.007)
In-state public enrollments only			Y	N	N
High school graduates sample			N	Y	Y
Final cumulative GPA			N	N	Y

otherwise appear similar based on observables. Based on the Washington data, we find that the misclassification bias on any college enrollment is approximately 55% of the probability of misreporting. We therefore interpret our results as suggesting that up to half of the enrollment effects estimated in previous studies may be explained by measurement error.

Some previous studies have relied on samples of high school graduates with retrospective information on dual enrollment participation. The results in Table 2 suggest that dual enrollment may influence the likelihood that students complete high school and thus appear in the data. In order to assess the influence of restricting the sample to high school graduates, we repeat our analyses using this sample. We report the results of this exercise in column (2) of Table 3, where the analysis sample includes only high school graduates. Despite the loss of some students who drop out of high school, the results are similar to those with the full sample. However, we do find some noticeable differences when we replace the academic achievement variables with measures taken at the time of graduation. In column (3), we replace tenth grade GPA with the final cumulative GPA for high school graduates. Participation in Running Start may improve students' preparation for upper level high school courses and thereby increase their cumulative GPA. On the other hand, the grading standards in college-level courses are likely stricter than high school courses and Running Start students may therefore graduate with lower GPAs than they would had they taken only high school courses. Under either of these scenarios, inclusion of a post-treatment academic measure may bias the estimated effects of Running Start. When we include final GPA, we find that estimated Running Start effects tend to be larger than with tenth grade GPA by about 2 percentage points. Cumulatively, we find that restricting the sample to high school graduates and using post-treatment measures of academic achievement raise the point estimates for the college enrollment outcomes by 2.5–3 percentage points.

Conclusion

We use a state longitudinal data system to evaluate the high school completion and college enrollment decisions of students in a popular dual enrollment program. The data used in this study improves on that used in recent studies of dual enrollment programs by including a more complete record of college enrollment and a sample of students taken before participation in the program. We find that students who participate in dual enrollment are more likely to attend any college immediately after high school graduation, but are no more likely to attend college full-time and are less likely to attend a four-year university. Moreover, the availability of richer data turns out to be quite important as we show that conditional differences in college

enrollment by participation status in Washington's dual enrollment program vary greatly depending on the types of postsecondary student information available. This suggests earlier studies lacking information on students' attendance at private or out-of-state colleges may have substantially misstated the benefits of dual enrollment programs.

We also find important heterogeneity in the outcomes of Running Start students depending on their initial preparation for college. Consistent with prior studies, we find that low-achieving participants later enroll in college at higher rates than expected. However, we also find that such students are more likely to drop out of high school or otherwise fail to complete a secondary diploma in four years. When considering eligibility requirements for dual enrollment programs, policymakers ought to balance the benefits of increased college access against the costs of high school dropout (Manski, 1989).

The positive result on college enrollment for low-performing students is consistent with prior empirical research on dual enrollment. As we discussed above, researchers have suggested several explanations for this finding. These include the reduced costs of college, the increased rigor of the high school curriculum, and the informational benefits to students of "trying out" college. The contrary results for high school completion, therefore, may seem counterintuitive. Yet, research on college persistence suggests several possible explanations for these effects as well. There is some evidence that the effects of rigorous high school curricula and exit requirements vary over the distribution of student ability (Clotfelter, Ladd, & Vigdor, 2012; Jacob, 2001). Students who are not well prepared for college-level courses may find it harder to complete high school graduation requirements through dual enrollment programs that offer such courses on a community college campus. While we cannot establish whether these effects are causal, our study points to two areas where more research is needed on dual enrollment programs. First, this suggests the need for more evidence on the long-term degree completion outcomes of dual enrollment participants, particularly for those with poor academic preparation. Second, there is relatively little evidence on which components of dual enrollment programs influence students' high school completion and college enrollment outcomes.

In the interim, policymakers may want to explore whether policies aimed at assisting struggling students to complete their high school graduation requirements, such as eligibility requirements, guidance counseling, or articulation agreements with participating colleges, increase high school completion and college enrollment rates. There is some evidence that student support services are particularly important for student success at non-selective colleges (Webber & Ehrenberg, 2010). Moreover, attendance at early college high schools, which couple dual enrollment with an emphasis on ancillary services and a college preparatory curriculum, appears to increase both high school

graduation and college enrollment (Berger et al., 2013; Edmunds, 2012). Likewise, Venezia and Voloch (2012) describe initiatives to integrate college placement assessments into the high school and dual enrollment curriculum.

Given the likelihood of selection into Running Start based on unobserved determinants of college attendance, we are cautious about drawing causal inferences based on the present analyses. In particular, our control vector is limited to high school academic variables and a limited set of socioeconomic variables. Using students' stated college intent at the time of entrance into Running Start, we present some evidence that selection may explain part of our results. We find some suggestive evidence that the diversionary effect of Running Start is likely inflated by differences in pre-treatment college plans. We also find some evidence that the diversionary effect is strongest among students who have nearly completed an associate degree and that the short-run effect on enrollment may not be predictive of longer-run effects on baccalaureate completion.

The increasing prevalence of state data warehouses that combine records from K–12 and postsecondary agencies with private and out-of-state college attendance should provide an opportunity to better study dual enrollment programs, including more quasi-experimental evidence of program impacts. The use of samples taken before program participation with more complete information on college enrollment expands the range of causal questions that can be posed. In particular, rigorous analysis of the effects of dual enrollment participation on overall educational attainment remains an important topic for future research.

APPENDIX A. CLASSIFICATION ERRORS IN THE NSC DATA

There are several sources of possible classification error in our NSC data, many of which are documented in great detail by Dynarski et al. (2013). In addition to these are a few that are particular to our dataset. In many regressions, we code students by their full-time enrollment status, which is missing for some students in the NSC data. We do not count these students as being enrolled full-time in the analyses in the text. However, a simple bounding exercise suggests that the maximal bias from this source of misclassification is likely to be very small. We therefore focus on the other sources of missing enrollments in our data.

The NSC data includes information on enrollment for students at covered institutions who do not block release of their enrollment records. We further lack information on a number of students whose records were not submitted by ERDC to NSC. Most of these are students who did not complete an on-time high school diploma, but some are coded in our data as having graduated. We consider each of these sources of missing data in turn.

Note that all of our classification errors are false negatives; that is, we incorrectly classify some students who attend college as not enrolling. We first introduce some notation to ease the exposition. Let $D = 1$ indicate that a student is in our analytic

sample; $H = 1$ denote that a student graduates high school; $C = 1$ denote that a student attends college; and $W = 1$ denote a student attends college in a public postsecondary institution in Washington State. Then the forms of misclassification are:

1. Students whose records are not submitted to NSC because they do not have a standard high school diploma, but who do attend some postsecondary institution ($H = 0$, $S = 0$, $C = 1$, $W = 0$).
2. Students who obtain a high school diploma, but are not submitted for matching to NSC ($H = 1$, $S = 0$, $C = 1$, $W = 0$).
3. Students who attend an institution and blocked release of NSC records ($B = 1$, $C = 1$, $W = 0$).
4. Students who attend an institution not covered by NSC ($U = 1$, $C = 1$, $W = 0$).

Note that these are mutually exclusive so that the total probability of misclassification is summative over these possibilities.

We first assume that students who fail to graduate from high school do not attend private or out-of-state institutions:

$$\Pr(H = 0, C = 1, W = 0) = 0.$$

If we instead assume that high school non-completers enroll in private or out-of-state institutions at a similar rate as high school graduates, we can estimate

$$\Pr(H = 0, C = 1, W = 0)$$
$$= \Pr(C = 1, W = 0 \mid H = 0) \Pr(H = 0)$$
$$= \Pr(C = 1, W = 0 \mid H = 1) \Pr(H = 0)$$
$$= \Pr(H = 1, C = 1, W = 0) [\Pr(H = 0) / \Pr(H = 1)]$$

As an extreme upper bound, therefore, we estimate that only 1.8% of students are misclassified as not attending college due to the non-submission of high school non-completers. This should be quite conservative since it does not appear that many students who fail to complete high school attend private or out-of-state institutions. Of the 1,036 students lacking a high school credential that were submitted to NSC, only 17 (1.6%) attended a college covered by that sample. This suggests a misclassification probability of about 0.0016 (0.10 * 0.016), so we assume this probability is 0 for estimation purposes.

We begin by estimating the probability that a student has a record submitted to NSC and attends college outside the Washington public university system conditional on inclusion in our analytic dataset. This probability will be useful for several of the calculations later on. Let A_0 denote this event:

$$A_0 = 1(C = 1, W = 0, S = 1)$$

Note that this is complicated by the fact that we do not observe college attendance for all of these students; some students with NSC submissions attend uncovered institutions or have their records blocked from release to third parties. Nonetheless, we can use two pieces of available information to estimate this probability under reasonable assumptions. The first is the coverage rates estimated by Dynarski et al.

(2013), which can be used to provide an estimate of the coverage rate conditional on attendance outside the schools covered by the ERDC data. The second is the NSC blocked records reports for the ERDC submissions, which can be used to estimate the blocked record rate conditional on attendance at a non-ERDC school. Putting these together, we have

$$\begin{aligned}
\Pr(A_0 = 1 \mid D = 1) &= \Pr(A_0 = 1, B = 0, U = 0 \mid D = 1) \\
&+ \Pr(A_0 = 1, B = 1, U = 0 \mid D = 1) \\
&+ \Pr(A_0 = 1, U = 1 \mid D = 1) \\
&= \Pr(A_0, B = 0, U = 0 \mid D = 1) \\
&+ \Pr(B = 1, U = 0 \mid A_0 = 1, I = 1) * \Pr(A_0 = 1 \mid D = 1) \\
&+ \Pr(U = 1 \mid A_0 = 1, D = 1) * \Pr(A_0 = 1 \mid D = 1).
\end{aligned}$$

Collecting terms and rearranging, we have

$$\begin{aligned}
&\Pr(A_0 = 1 \mid D = 1) \\
&= [\ \Pr(A_0 = 1, B = 0, U = 0 \mid D = 1) / \\
&\quad (1 - \Pr(B = 1, U = 0 \mid A_0 = 1, D = 1) - \Pr(U = 1 \mid A_0 = 1, D = 1))\ ] \\
&= A_1 / (1 - A_2 - A_3).
\end{aligned}$$

The first term, A_1, is the probability that a student is observed in a private or out-of-state college in our dataset and is therefore easily estimated from the sample. The other two probabilities are not directly observed but can be estimated from available data. The second, A_2, is the probability that a student in our dataset attends an out-of-state or private college at an institution covered by NSC and blocks release of her record. The third, A_3, is the probability that a student in our sample attends an institution not covered by NSC.

We begin by estimating the probability that a student attends an uncovered institution conditional on being in our dataset and attending a college outside the Washington public college system, $\Pr(U = 1 \mid A_0 = 1, D = 1)$. While we do not have any direct information about students' attendance at such institutions, we do have estimates of the NSC institutional coverage rates from Dynarski et al. (2013) for states and sectors and data from IPEDS about the enrollment of Washington State students in each state and sector. From these data sources, we construct an estimate of the probability that a Washington State student who enrolls in a college outside the public university system enrolls in an uncovered institution. To do so, we first use the 2011 IPEDS fall enrollment counts for recent high school graduates to estimate the probability that a student who enrolls outside Washington's public colleges enrolls in each state, level, and sector (public, private not-for-profit, private for-profit). We then estimate the total coverage rate for Washington students by multiplying each weight by the sectoral coverage rates reported in Tables A2 - A6 of Dynarski et al. (2013). Taking the sum over all sectors, we arrive at an estimate of $\Pr(U = 1 \mid C = 1, W = 0)$.

Under the assumption that U id independent of (D, S) conditional on (C, W), we can use this as an estimate of the desired probability $\Pr(U = 1 \mid A_0 = 1, D = 1)$. That is, we assume that NSC coverage is independent of inclusion in our dataset and whether the student was submitted to NSC conditional on whether the student

attends college outside the public system. This assumption is likely violated for two reasons. First, the sample restrictions we impose on our data restrict the sample to students with above-average academic performance. We may therefore undercount students attending private, four-year colleges, which have a lower coverage rate. On the other hand, the IPEDS data include students who attend private high schools in Washington, which should tend to bias $\Pr(U = 1 \mid C = 1, W = 0)$ upward if such students are more likely than public high school students to attend private colleges. Note that these biases tend to operate in the opposite direction. Nonetheless, our estimated non-coverage rate is very close to both the Washington and national averages, and using these rates instead has little impact on the results.

It remains to estimate the probability of FERPA blocking. The NSC returns a report that indicates the number of blocked records. Because we only know the institution and blocked record rate from this data, we only have an estimate of

$$\Pr(B = 1 \mid A_0 = 1, U = 0),$$

whereas the bias term requires an estimate of $\Pr(B = 1, U = 0 \mid A_0 = 1, D = 1)$. We therefore estimate

$$\Pr(B = 1, U = 0 \mid A_0 = 1, D = 1)$$
$$= \Pr(B = 1 \mid U = 0, A_0 = 1, D = 1) \Pr(U = 0 \mid A_0 = 1, D = 1)$$
$$= \Pr(B = 1 \mid U = 0, A_0 = 1) \Pr(U = 0 \mid A_0 = 1),$$

where the second inequality follows from the same assumptions as above plus the assumption that B is independent of D given (A_0, U). With these estimates in hand, we can estimate the probability of misreporting due to M3 and M4.

The last source of measurement error is students who complete high school but are not submitted to NSC. We estimate the probability of misclassification under the assumption that the probability of college enrollment is independent of whether the student is submitted to NSC conditional on high school graduation. Note that this uses the previous assumption that $\Pr(C = 1, W = 0 \mid H = 0) = 0$. We then have

$$\Pr(C = 1, W = 0, S = 0 \mid D = 1)$$
$$= \Pr(C = 1, W = 0, S = 0, H = 1 \mid D = 1)$$
$$= \Pr(C = 1, W = 0 \mid H = 1, S = 0, D = 1) \Pr(H = 1, S = 0 \mid D = 1)$$
$$= \Pr(C = 1, W = 0 \mid H = 1, S = 1, D = 1) \Pr(H = 1, S = 0 \mid D = 1)$$
$$= \Pr(C = 1, W = 0, H = 1, S = 1 \mid D = 1) *$$
$$\quad [\Pr(H = 1, S = 0 \mid D = 1) / \Pr(H = 1, S = 1 \mid D = 1)$$
$$= \Pr(A_0 = 1 \mid D = 1) *$$
$$\quad [\Pr(H = 1, S = 0 \mid D = 1) / \Pr(H = 1, S = 1 \mid D = 1)]$$
$$= 0.0053.$$

Note that the first term is the same we estimated earlier. The other terms can be estimated directly from the sample.

Finally, we combine these to estimate the total misreporting rate. We have

$$\Pr(M = 1 \mid D = 1)$$
$$= \Pr(M1 = 1 \mid D = 1) + \Pr(M2 = 1 \mid D = 1) + \Pr(M3 = 1 \mid D = 1) + \Pr(M4 =$$

$1 \mid D = 1)$
$= 0 + \Pr(A_0 = 1 \mid D = 1) \; [\Pr(H = 1, S = 0 \mid D = 1) \, / \, \Pr(H = 1, S = 1 \mid D = 1)]$
$+ \; [\; \Pr(B = 1, U = 0 \mid A_0 = 1, D = 1) + \Pr(U = 1 \mid A_0 = 1, D = 1) \;]$
$* \; \Pr(A_0 = 1, B = 0, U = 0 \mid D = 1) \, / \, [1 - \Pr(B = 1, U = 0 \mid A_0 = 1, D = 1)$
$- \; \Pr(U = 1 \mid A_0 = 1, D = 1)],$

where the *M1*, *M2*, *M3*, and *M4* correspond to the types of misclassification enumerated earlier and *M* denotes misclassification from any source.

Using this data, we can attempt to recreate the biases in the linear probability model using the formulas of Meyer and Mittag (2013). We first summarize the assumptions we have made thus far.

1. $\Pr(C = 1, W = 0, H = 0) = 0$.
2. U indep. $(D, S) \mid (C, W)$.
3. B indep. $(D, S) \mid (C, W)$.
4. (C, W) indep. $S \mid (D, H)$.

Following Meyer and Mittag (2013), define the measurement error in the dependent variable as

$$u = \begin{cases} -1 & \textit{if false negative} \\ 0 & \textit{if reported correctly} \\ 1 & \textit{if false positive} \end{cases}$$

The bias in the OLS coefficients is given by

$$d = (X'X)^{-1} X'u,$$

which, given the structure of the measurement error, can be rewritten as

$$d = -(X'X)^{-1} N_{FN} \, \mathbf{x}_{FN},$$

where N_{FN} is the number of false negatives and $\mathbf{x}_{FN}$ is the means of the covariates among the false negatives. Our estimate of the bias then becomes

$$d = - N(X'X)^{-1} \Pr(M = 1 \mid D = 1) \, \mathbf{x}_{FN},$$

where the mean is taken over the observations that are observed to attend college outside the Washington public system ($C = 1, W = 0, S = 1, B = 0, U = 0, D = 1$).

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