CCRC COMMUNITY COLLEGE RESEARCH CENTER

TEACHERS COLLEGE, COLUMBIA UNIVERSITY

Does Taking a Few Courses at a Community College Improve the Baccalaureate, STEM, and Labor Market Outcomes of Four-Year College Students?

Vivian Yuen Ting Liu
Maggie P. Fay

July 2020

CCRC Working Paper No. 122

Address correspondence to:

Vivian Yuen Ting Liu
Postdoctoral Research Associate
Community College Research Center
Teachers College, Columbia University
525 W. 120th St., Box 174
New York, NY 10027
212-678-3091
Email: ytl2102@columbia.edu

Funding for this study was provided by the Bill & Melinda Gates Foundation. The findings and conclusions contained within are those of the authors and do not necessarily reflect positions or policies of the foundation.

Abstract

Nationally, 38.5% of the students who began at a four-year college in 2011-12 attended another college within the first six years of college entry, and more than half of these students attended a community college. Eight percent of students who began at a four-year institution took up to 10 credits at a community college during the same period. Given the number of students involved, it is helpful to better understand how this kind of postsecondary enrollment pattern affects students. This paper considers a sample of "supplementally enrolled" students who began in and primarily enrolled in four-year colleges but who also earned limited numbers of credits at community colleges. We use student data from the Education Longitudinal Study of 2002 and a propensity score matching approach to compare key outcomes of four-year college students who earned 1 to 10 credits at two-year colleges during their first three years at college with those of four-year college students who never earned credits in a two-year college. Many of the supplementally enrolled students took STEM courses at a two-year college. We find that the supplementally enrolled students had higher STEM and total credits earned, higher bachelor's degree attainment, and better employment outcomes than the students who never earned credits from a two-year college. Subgroup results also suggest that supplemental enrollment can potentially improve STEM degree attainment outcomes, particularly for low-socioeconomic-status and female students.

Table of Contents

1. Introduction

Nationally, 38.5% of the college students who began at a four-year institution in the academic year 2011-12 attended another institution in the first six years of college, and more than half of them attended a community college (Shapiro et al., 2018). Some students who begin at a four-year college and then enroll in a two-year college eventually transfer to the community college permanently,[1] while others take a few courses at a community college while continuing to attend their four-year college. The latter group of students, who presumably intend to earn a bachelor's degree, are the focus of this paper.[2] For ease of exposition, we generally use the terms *supplemental enrollment* and *supplementally enrolled* in this paper to describe students who began their first term in college exclusively at a four-year college and who at some time over the course of the next three years earned from one to 10 credits at two-year colleges.[3]

There are three main reasons why supplemental enrollment may benefit four-year college students. First, the ability to supplementally enroll increases course options and availability, which allows four-year students to take courses that are either not offered in a particular semester or are in conflict with their course schedule at their four-year college. Two-year colleges tend to be more geographically accessible and offer more flexible schedules, often offering some courses year-round. Four-year students can potentially reduce time-to-degree by taking two-year courses in the summer or outside of four-year class time. Second, community college courses are considerably cheaper, which may incentivize students to take some electives or prerequisite courses to lower their overall cost of a baccalaureate education. Third, supplemental enrollment may serve as a strategy for accruing STEM credits, particularly for students from subgroups traditionally underrepresented in STEM. The same subgroups of students who are underrepresented in STEM programs—including female, Black, and Latinx students and students from low

[1] Previous literature has generally considered four-year college students with more than 10 two-year credits as reverse transfer students who have an intent to earn a community college degree (e.g. Adelman, 1999; Kalogrides & Grodsky, 2011).

[2] This type of enrollment pattern can be considered a type of "swirling," and it has also been described as "cross-enrollment," "dual enrollment," "simultaneous enrollment," "concurrent enrollment," or "double dipping."

[3] Four-year students rarely supplementally enroll at private two-year institutions. Most supplemental enrollment takes place at public two-year colleges. And it is important to recognize that *supplementally enrolled* students are not necessarily enrolled at both a two-year and a four-year college in the same term.

socioeconomic backgrounds—are overrepresented in community colleges. Four-year students from these subgroups may find community colleges to be a more academically supportive environment to earn STEM credits. Alternatively, since grades earned in transfer courses generally are not included in students' grade point averages (GPA) in four-year institutions, students may opt to take courses they perceive to be challenging, such as STEM requirements, at two-year colleges instead.

The key research question this study explores is whether supplemental enrollment behavior, in which four-year college students take a small number of courses at a community college, improves the academic and earnings outcomes of bachelor's degree students. Two-year colleges differ from four-year colleges along several important dimensions, including structure, administration, staffing, scheduling, and student composition. Thus, while earning small numbers of credits at community college may confer some of the benefits mentioned above, mixing in two-year courses may also make bachelor's degree attainment more challenging.[4]

In this paper, we estimate the academic and earnings outcomes of supplementally enrolled students using propensity score matching (PSM) methods and data from the Education Longitudinal Study of 2002 (ELS). We find that supplemental enrollment is correlated with an increase in total credits earned and improved bachelor's degree attainment and employment outcomes, compared to enrollment among four-year college students who never earned two-year credits. Subgroup analysis reveals that these results are much stronger for female students, Black and Latinx students, and students with low socioeconomic status (SES). We also find that supplemental enrollment is positively correlated with STEM credit accumulation and the likelihood of completing a bachelor's degree in STEM-related fields for female and low-SES students. Finally, we find that, despite earning more credits, the amount of undergraduate and graduate loan debt nine years from initial college entry of supplementally enrolled students did not differ with any statistical significance from four-year college students who did not earn any credits at community colleges.

[4] Though not explored in this paper, the lack of efficient articulation agreements between colleges may also result in excess credits and wasted time and money among supplementally enrolled students if the four-year institutions that students enrolled in do not accept for transfer credits earned at two-year colleges.

This paper extends the literature in two main ways. First, we look at the types of courses that supplementally enrolled students take at community colleges, which points to a possible mechanism driving supplemental enrollment behavior. Second, we use a nationally representative dataset of students who enrolled in college in the mid-2000s to explore the academic and employment outcomes of supplementally enrolled students. Only a few papers have attempted a rigorous examination of outcomes for four-year students taking any community college courses (e.g., Kalogrides & Grodsky, 2011; Liu, 2016; Wang & Wickersham, 2013; Wang & McCready, 2013). And even fewer have focused on the relationship between supplemental enrollment, STEM, and labor market outcomes.

Supplemental enrollment among four-year college students deserves more attention. The prevalence of enrollment mobility creates challenges for institutions and policymakers, who are often not fully aware of the ubiquity of supplemental enrollment patterns and the outcomes of supplementally enrolled students. Understanding patterns of supplemental enrollment is crucial in providing academic guidance to students and building processes for tracking transfer credits among colleges and college systems.

2. Relevant Literature and Conceptual Grounding

2.1 Diverse Enrollment Patterns and Academic and Labor Market Outcomes

Patterns of enrollment across multiple institutions of higher education have become increasingly commonplace since the 1990s (Adelman, 1999; 2005; McCormick, 2003; Townsend, 2001). Instead of treating college as a one-stop for higher education, students' diverse enrollment pathways have resembled a shopping process whereby they pick and choose courses and institutions according to their needs (Adelman, 1999). Researchers have documented a wide array of circuitous enrollment patterns that highlight the fact that undergraduate students have high levels of mobility, often enroll in multiple institutions throughout their college careers, and do not follow linear paths of transfer (Bach et al., 2000; Desjardins, 1999; Goldrick-Rab, 2006; de los Santos & Sutton, 2012).

Studies on diverse enrollment patterns taken by students who begin at four-year colleges offer classifications for a multitude of education pathways and course-taking patterns (de los Santos & Wright,1990; Kintzer, 1983; Cooley, 2000; McCormick, 2003). Using the National Education Longitudinal Study of 1988 (NELS:88) and logistic regression, Adelman (1999) carried out one of the earliest national studies examining academic outcomes of diverse enrollment patterns and found that one in four students from the high school class of 1992 started at a four-year institution prior to attending a community college by 2000. Forty-two percent of these students were "four-year drop-ins," earning 10 or fewer two-year credits. These students are supplemental enrollment students under our definition; their bachelor's degree completion rate was 87%. Yet the rest of the four-year students who earned higher numbers of credits at community college had lower bachelor's degree completion rates. Twenty-eight percent of the students were "swirlers," earning at least 30 community college credits. Their bachelor's degree completion rate was 56%. The remaining 30% constituted "true reverse transfer" students who started at a four-year college and ended at a community college. These students had poor academic outcomes; only 17% earned an associate degree.

Several more recent studies have found positive academic outcomes associated with attending multiple institutions, including higher college GPA and higher rates of persistence and bachelor's degree attainment (Crisp, 2011; McCormick, 2003; Wang, 2012a; Wang & Wickersham, 2013). These studies focused exclusively on students enrolled at multiple institutions simultaneously (the present study is not limited to this population). Wang and McCready (2013) used a PSM approach to examine outcomes for students with a range of simultaneous enrollment patterns, including attending multiple community colleges or multiple four-year colleges in the same term, and attending both two and four-colleges in the same term. The authors found that both types of simultaneous enrollment increased the likelihood of persistence and educational attainment for students who began at both four-year and two-year colleges.

To our knowledge, only two papers have examined the labor market outcomes of students who began at four-year colleges and enrolled later in community college. Using NELS:88 data and PSM methods, Kalogrides and Grodsky (2011) sought to explore how earning at least 10 community college credits affects the earnings of four-year starters.

The authors concluded that their earnings estimates were imprecise and showed no significant difference in earnings between students with at least 10 community college credits and four-year students without any community college credits. Using state administrative data and the distance to the closest community college as an instrumental variable, Liu (2016) examined four-year starting students with any two-year enrollment in non-summer terms who had less than a 3.0 GPA in their first semester at their initial four-year college. She found an earnings advantage for female reverse transfer students over female students who did not transfer.

2.2 Impacts of Supplemental Enrollment

In theorizing how supplemental enrollment influences students' academic and labor market outcomes, we rely on the human capital investment model for conceptualizing students' enrollment decisions and potential outcomes (see Perna, 2006).

Under the human capital investment model, individuals decide where and how much to invest in education based on monetary and non-monetary costs in relationship to the expected benefits of higher education (Becker, 1993). Holding predicted benefits constant, supplemental enrollment at community colleges can lower the overall cost of college by providing more affordable course options. The average cost of in-state tuition for a full-time enrolled student at a public four-year college was $10,040 in 2019-20, and in-district tuition and fees at a public two-year college was $3,730 in the same period (Ma, Baum, Pender, & Libassi, 2019). Supplemental enrollment may also lower the non-monetary costs of college, such as time cost, by increasing the flexibility, availability, and geographical accessibility of courses (Wang & McCready, 2013). With increased availability of courses, four-year students can potentially reduce their time-to-degree by taking two-year courses in the summer or outside of four-year class time.

Further, students who aspire to earn bachelor's degrees in STEM fields may experience barriers in four-year colleges that make it difficult for students, particularly those traditionally underrepresented in STEM, to be successful. As many as 45% of STEM four-year college graduates nationwide earn some credits in community colleges (Mooney & Foley, 2011). STEM majors generally have higher grading standards and require more study time than non-STEM majors (Arcidiacono, 2011; Rask, 2010; Johnson, 2003). Earning lower grades in STEM relative to non-STEM courses may therefore deter students from persisting in STEM majors (Ost, 2010; Griffith, 2010; Chen, 2013). Since transfer credits are often not counted toward students' GPAs at their primary institution (Moldoff, 2006), some students may opt to take required courses in subjects that are perceived to be difficult, such as those in STEM fields (McCormick, 2003), at a two-year institution to maintain a higher overall or major-specific GPA.

Taking STEM courses at community colleges may be particularly beneficial to students who are underrepresented in STEM fields, including women, Black and Latinx students, and students from lower-income backgrounds. Research suggests that underrepresented groups in STEM may have weaker confidence about their academic abilities in STEM and therefore greater sensitivity to course grades (Sekaquaptewa & Thompson, 2003; Ülkü-Steiner et al., 2000). The differential sensitivity has been shown to negatively affect the persistence of female students in STEM majors (Owen, 2008). For students who are underrepresented in STEM fields, taking STEM courses in community colleges could provide a two-fold benefit: It could protect their GPAs from the impact of a weaker course grade, and it could offer a more supportive learning environment than they would have in their four-year college, thereby bolstering their academic confidence.

Community colleges may also provide better learning environments to underrepresented students in STEM, who may lack a sense of belonging in STEM classrooms (Johnson, 2012). Research has shown that female, Black, and Latinx students who encounter negative climates in core STEM courses are less likely to persist and complete STEM degrees (Seymour, 1995; Seymour & Hewitt, 1997; Tobias, 1992). Introductory STEM courses are often very large lecture classes where students experience little direct interaction with instructors or receive little individualized attention; these factors have been shown to be particularly disadvantageous to retention for underrepresented students (Barr, Gonzalez, & Wanat, 2008; Carlone & Johnson, 2007). Researchers have also pointed out that community colleges generally focus on teaching more than research when compared to research universities (Dowd, Cheslock, & Melguizo, 2008), which may be particularly helpful for students with less confidence about their abilities in STEM courses. Underrepresented students in STEM have reported that community colleges foster more positive interactions with faculty and offer more nurturing environments than four-year colleges do (Reyes, 2011; Townsend, 2008).

Nonetheless, a student's ability to complete a bachelor's degree may depend not only on the number of credits they complete through supplemental enrollment but also on the quality and content of the courses, which can differ between two-year and four-year institutions, as well as on how successful the student is in transferring those credits between institutions (Behrman & Birdsall, 1983). Alfonso (2006) showed that, compared to traditional four-year college students, community college students have lower degree aspirations and poorer academic performance. Some researchers and educators are concerned that the lower peer quality and degree aspirations at community colleges may negatively influence students intending to earn a bachelor's degree (Kalogrides & Grodsky, 2011; McCormick, 2003). Furthermore, some research suggests that community colleges suffer from grade inflation and less rigorous evaluation of performance compared to four-year colleges (Friedl, Pittenger, & Sherman, 2012; Schutz, Drake, & Lessner, 2013). As a result, supplementally enrolled students may receive higher grades in courses they take at a community college but still end up less well prepared for subsequent upper-level courses at their primary four-year college. Furthermore, supplementally enrolled students may experience loss of credits. Using Beginning Postsecondary Students data, Monaghan and Attewell (2015) found that only 58% of two-to-four-year transfer students are able to transfer most of their credits to their four-year institutions. For four-year college students supplementally enrolling in a two-year institution, earning community college credits may cost them unnecessary time and money if they do not receive proper guidance from an advisor at their primary institution.

In addition to explaining how supplemental enrollment may change the level of educational investment, the human capital theory is also helpful in linking supplemental enrollment to employment outcomes. The model holds that differences in the level of investment in human capital, such as education and training, give rise to different productivity and lead to earnings differentials (Becker, 1993; Paulsen, 2001), and that individuals receive similar amounts of human capital and future earnings from their attained bachelor's degrees (Card, 1995). Accordingly, if two-year credits lead to higher baccalaureate completion, supplemental enrollment students should have higher future earnings than students who do not supplementally enroll. And since STEM fields generally have higher pay, if supplemental enrollment improves STEM degree completion, supplemental enrollment students should also be able to attain higher pay after graduation.

Supplemental enrollment in a two-year college may influence primarily four-year college students in many different ways, both positively and negatively. To what extent these factors affect STEM attainment, bachelor's degree completion rates, and labor market outcomes remains an open empirical question.

3. Data and Summary Statistics

3.1 Data Description

The Education Longitudinal Study of 2002 (ELS), conducted by the National Center for Education Statistics, is a nationally representative survey of 15,360[5] students who were in 10th grade in 2002. These students took part in an additional survey in 2004 (for most students, their final year of high school), and the sample was updated to be representative of students enrolled in 12th grade in the spring of 2004. Additional follow-ups occurred in 2006 (when most students had completed some college) and in 2012 (by which time many had completed or terminated their postsecondary education). In addition to survey data, the ELS also provides high school and postsecondary transcripts.

The key advantage of the ELS is that it is one of two nationally representative datasets with comprehensive labor market outcomes and full high school and college transcript records for a cohort of college students who graduated or left college after 2000. The ELS data includes a large set of demographic and pre-college variables, which are crucial for using a PSM methodological approach, as we do here. In addition, the ELS postsecondary education transcript data includes records on all courses attempted and institutions attended, which enables us to analyze student enrollment patterns across colleges.

The ELS sample contains 11,600 students who had reported any postsecondary attendance during the third (2012) survey wave. Of these students, 6,820 first attended a

[5] All unweighted sample sizes are rounded to the nearest 10.

four-year college and 4,020 first attended a two-year college. After dropping those without any transcript data or labor market information and those who started at both two-year and four-year colleges in the same term, the final unweighted sample consists of 6,440 students who started at a four-year institution.

We draw a substantial number of our covariates from the 2004 survey, when students were in their final year of high school. Demographic variables include gender, race/ethnicity, age, distance to two- and four-year colleges, SES, and high school sector and region. To control for first-college first-term measures, we also use variables from the 2006 survey, such as months between high school and first college attendance, first-term credits earned and GPA at the initial four-year college, and the urbanicity of and financial aid offered at the initial institution. We draw a majority of the outcome variables from the 2012 survey data, including highest degree earned, STEM degree attainment, debt, and labor market information. We calculate two- and four-year college credits earned, STEM credits earned, and GPA from the postsecondary transcript data.

3.2 Summary Statistics

Table 1 provides a descriptive summary of the 6,440 students who started at a four-year institution and compares demographic and academic characteristics of students with different enrollment patterns. Column 1 presents the statistics for the overall sample. Columns 2, 3, and 4 display the same information for students who, in the first three years, earned no two-year college credits, earned 1 to 10 two-year college credits (the *supplementally enrolled* students), and earned more than 10 two-year credits (potentially representing *reverse transfer* students who intend to earn a two-year college credential), respectively.[6]

About 12% of the four-year students in the sample earned credits from two-year colleges in their first three years; about two thirds of these supplementally enrolled, and about one third earned over 10 credits at two-year colleges. Our analytical sample consists of students with no two-year college credits and of supplementally enrolled students, who earned 1 to 10 credits. Column 4 indicates that students with more than 10 two-year credits are different from students with 1 to 10 two-year credits (column 3)

[6] High school–college dual enrollment credits are excluded from all credit counts.

along some dimensions. Compared to supplementally enrolled students, reverse transfer students were less likely to be female and to be from a minoritized group, and they were more likely to have a poorer high school performance. They were also more likely to first attend a public and non-selective four-year institution. This supports our sample selection in excluding students with over 10 two-year credits, as their demographic characteristics and pre-college preparation are dissimilar to students with fewer two-year credits.

Columns 2 and 3 compare students without any two-year college credits and supplementally enrolled students. Column 5 shows the *t*-statistics of the differences across these two groups for each variable. Female and Asian students were more likely to supplementally enroll, though supplemental enrollment students were similar in SES to those who never attended a two-year college. Distance also seems to matter. Supplementally enrolled students tended to live farther from any four-year institutions and closer to a two-year college, and had a higher number of two-year colleges within 25 miles of their home.

Regarding high school performance and degree aspiration, supplementally enrolled students had higher high school GPAs, participated in more extracurricular activities, and had higher postsecondary aspirations than students who never attended a two-year college. Sixty-eight percent of the supplementally enrolled students started at a public four-year institution (as opposed to a private one), in comparison to 60% of students who never attended a two-year college. They were also more likely to attend moderately selective institutions and less likely to start at a selective institution than students with no two-year enrollment.

Table 1
Descriptive Statistics of Four-Year Beginning Students in ELS 2002

Variables	Total	Two-Year Credits Earned in First Three Years: 0	1-10	> 10	*t*-statistics (0 Two-Year Credits – 1-10 Two-Year Credits)
Sample size (unweighted, rounded to nearest 10)	6440	5690	510	250	
Demographic characteristics					
Female	54%	53%	64%	56%	-4.62*
White, non-Hispanic	61%	61%	59%	62%	1.10
Black/African American	10%	10%	9%	9%	0.85
Hispanic	8%	8%	7%	7%	0.79
Asian	11%	11%	15%	10%	-3.01*
Other race/ethnicity	9%	9%	10%	11%	-0.24
Missing race/ethnicity variable	5%	5%	4%	5%	0.51
Born in 1985	33%	33%	28%	32%	2.40*
Born in 1986	65%	65%	70%	66%	-2.57*
English as a second language	13%	13%	14%	11%	-0.21
SES in lowest quintile	11%	11%	11%	13%	-0.04
SES in second lowest quintile	16%	16%	15%	13%	0.73
SES in second highest quintile	25%	25%	25%	28%	0.20
SES in highest quintile	43%	43%	45%	40%	-0.91
Missing SES quintile information	5%	5%	4%	5%	0.51
Miles to closest four-year college	14.4	14.2	16.5	15.7	-3.17*
Miles to closest two-year college	11.4	11.5	9.9	11.3	2.71*
Number of two-year colleges within 25 miles	4.3	4.2	5.5	5.2	-5.66*
Started college in 2004–05	93%	92%	98%	97%	-4.70*
High school information					
Cumulative GPA	3.17	3.17	3.27	3.10	-3.63*
Number of extracurricular activities	2.51	2.51	2.62	2.29	-1.02
Ever dropped out of high school	1%	1%	0%	1%	1.97*
Intended to earn two-year credential	4%	4%	1%	8%	2.60*
Intended to earn four-year credential	32%	33%	30%	36%	1.26
Intended to earn graduate credential	56%	56%	63%	48%	-3.19*

Note. Unweighted sample sizes are rounded to the nearest 10.

*$p < 0.1$.

Table 1 (cont.)
Descriptive Statistics of Four-Year Beginning Students in ELS 2002

Variables	Total	Two-Year Credits Earned in First Three Years = 0	1-10	> 10	*t*-statistics (0 Two-Year Credits – 1-10 Two-Year Credits)
College information					
First attended a public four-year	61%	60%	68%	72%	-3.48*
First attended a non-profit four-year	31%	32%	26%	24%	2.32*
First attended a for-profit four-year	4%	4%	1%	2%	3.73*
First attended a selective four-year	32%	33%	29%	22%	1.99*
First attended a moderately selective four-year	34%	32%	41%	32%	-4.05*
First attended an inclusive four-year	11%	11%	10%	13%	0.79
Credits earned in the first term	9	8	10	9	-5.48*
GPA in the first term	3.08	3.09	3.09	2.73	0.13
Total four-year credits earned	107	107	113	86	-2.37*
Total two-year credits earned	4	0	10	46	-19.26*
Total credits earned	111	109	123	130	-5.77*
Aid offered at the first institution	63%	63%	67%	65%	-2.14*
Cumulative Pell by 2012	$4,968	$4,953	$4,973	$5,407	0.08
Academic and loan outcomes in 2012					
Highest degree earned: associate degree	4%	4%	2%	15%	2.54*
Highest degree earned: bachelor's degree	36%	36%	44%	26%	-6.03*
Ever enrolled in graduate school	34%	34%	42%	29%	-3.88*
Highest degree earned: graduate degree	26%	25%	31%	20%	-2.97*
Received a STEM-related BA	17%	17%	24%	13%	-3.82*
Amount borrowed for undergraduate loans	$11,320	$11,541	$9,253	$10,950	2.85*
Labor market outcomes					
Full-time employed in 2012	72%	72%	75%	70%	-6.97*
Average # of hours worked per week in 2012	48	49	44	46	-0.67
Annual earnings in 2011–12 school year	$30,502	$30,307	$32,417	$30,704	-3.49*
Hourly wage in 2012	19	19	20	18	-2.73*
Job satisfaction: usefulness of degree	60%	59%	69%	62%	-4.28*
Job satisfaction: family-work balance	67%	66%	76%	71%	-4.67*
Job satisfaction: leisure	62%	62%	69%	62%	-2.99*

Note. Unweighted sample sizes are rounded to the nearest 10.

*$p < .1$.

As shown from the *t*-statistics, there are significant differences across several dimensions in student composition between those who earned no two-year credits and those who supplementally enrolled. These differences highlight the need for an analytic approach that takes into account the selection bias into supplemental enrollment when comparing the outcomes of supplementally enrolled students and traditional four-year students who never enrolled in two-year colleges.

3.3 Enrollment Patterns and Institutional Selectivity

On average, supplementally enrolled students earned 10 credits at community colleges (including credits earned beyond the three-year period of the study), and 73% of them earned at least some STEM credits at community colleges. Those with STEM credits earned an average of 7.5 STEM credits in total at all colleges attended. The likelihood that students would engage in supplemental enrollment varied by the selectivity of their initial institution. For example, Table 1 shows that students who started at selective four-years were less likely to supplementally enroll than students who started at moderately selective four-years.

Table 2 presents the credit accumulation patterns for the whole sample disaggregated by initial institution's selectivity. Four key observations emerge. First, four-year beginning students on average accumulated 107 four-year and 4 two-year college credits in the first three years of enrollment. Given that only 25% of the two-year college credits were earned in the summer, a substantial number of credits were accumulated in the fall and spring semesters. Second, close to half of the four-year and two-year college credits were in STEM fields. Students attending more selective colleges earned more four-year STEM credits. Third, the average GPA earned was higher at two-year colleges than at four-year colleges. Finally, 15% of the students from highly selective institutions earned credits from two-year institutions at some point in their college careers. For these students, one third of the credits earned at two-year colleges were in STEM fields.

The generally high proportion of STEM credits earned at two-year colleges provides support for the hypothesis that some four-year students may strategically take courses in subjects that they perceive to be more difficult in four-year colleges, such as STEM courses, in community colleges to avoid getting lower grades.

Table 2
Descriptive Statistics of Two-Year College Credit Accumulation Patterns Among Initial Four-Year College Students Across Initial Institution's Selectivity

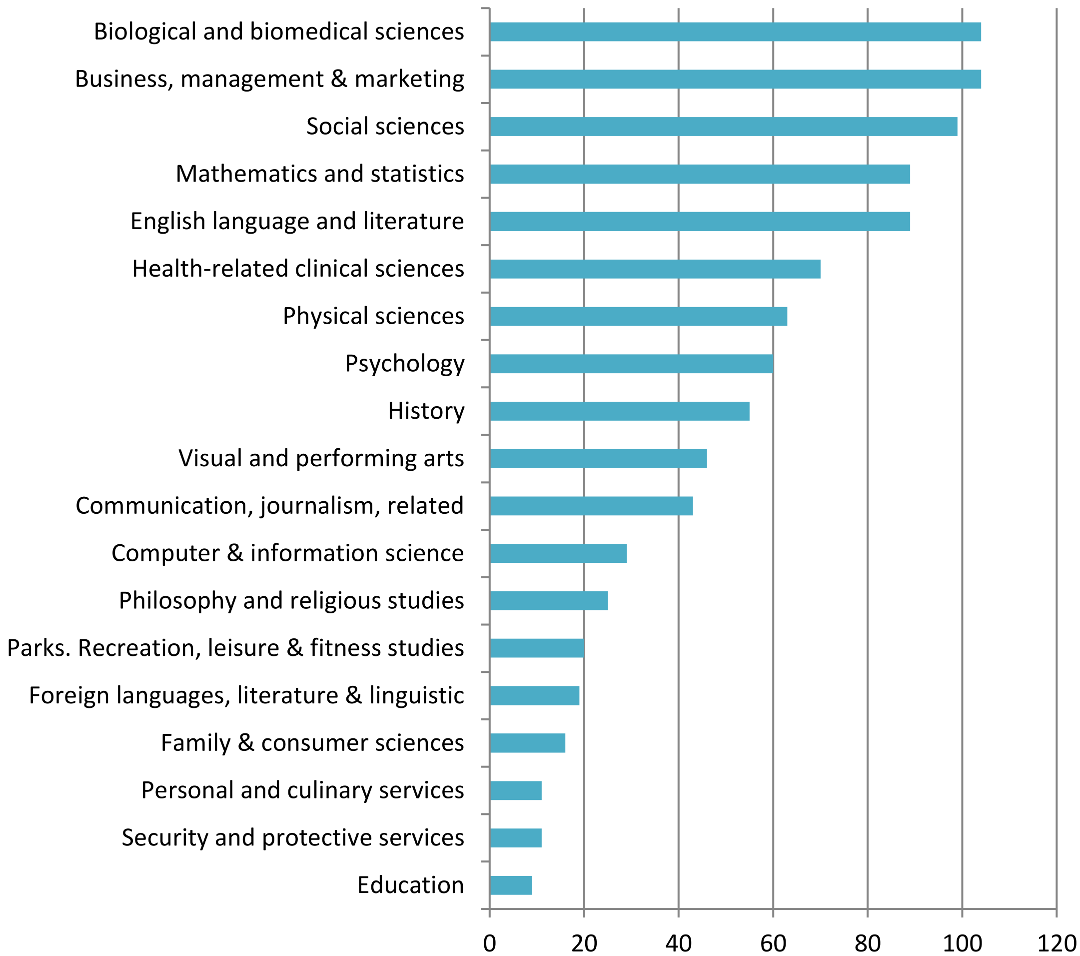
	All	Selectivity Not Classified	Inclusive	Moderately Selective	Highly Selective
Observations	6,440	1,470	720	2,160	2,090
Ever earned two-year credits	18%	18%	18%	21%	15%
Earned 1-10 two-year credits in first 3 years	8%	7%	7%	10%	7%
Earned more than 10 two-year credits in first 3 years	4%	4%	5%	5%	3%
Total two-year credits earned	4	5	4	4	3
Total four-year credits earned	107	80	99	114	120
Total two-year credits earned in the summer	1	1	1	1	1
Total four-year credits earned in the summer	7	8	6	6	6
Total two-year credits earned in STEM field	2	2	2	2	1
Total four-year credits earned in STEM field	49	34	44	50	61
Credits earned in first term of two-year Institutions	0	0	0	0	0
Credits earned in first term of four-year Institutions	9	5	8	10	10
GPA at two-year institution	3.26	3.11	3.09	3.27	3.46
GPA at four-year institution	3.08	2.87	2.95	3.09	3.25
GPA in first term of four-year institution	3.08	2.87	3.01	3.09	3.19

Note. Unweighted sample sizes are rounded to the nearest 10.

3.4 Courses Taken

Figure 1 presents the number of courses taken at two-year colleges by subject by supplementally enrolled students (those who earned 1-10 credits at two-year colleges in the first three years). The three most popular subjects were (1) biological and biomedical sciences, (2) business, management, and marketing, and (3) social sciences. At least half of the two-year courses taken by all four-year students were in STEM fields.

Figure 1
Number of Courses Taken in Two-Year Colleges by Supplementally Enrolled Four-Year Students



4. Econometric Methods

4.1 The Ideal Experiment

The ideal experiment to answer our research question would be to randomize students into two groups, in which those in one group never take any two-year course and those in the other group take a randomized number of between 1 to 10 two-year credits in the first three years after their initial enrollment at a four-year college. Then one could use the following ordinary least squares (OLS) equation to compare the academic and labor market outcomes of supplementally enrolled students and students who earned no two-year credits, controlling for student characteristics.

$$Y_i = \beta_1 supp_i + \beta_2 X_i + \epsilon_i \tag{1}$$

At the student level, $supp_i$ indicates whether individual i supplementally enrolled in a two-year college after initial enrollment at a four-year college. Y_i is the outcome approximately eight years from initial college entry. X_i denotes a vector of pre-treatment student demographic and academic measures.

Realistically, this kind of randomization would be impossible. A major challenge in looking at enrollment at two-year colleges is that students do not choose their pathway randomly. Students with certain characteristics may find two-year college courses more appealing than other students. For example, higher performing students and students from groups underrepresented in STEM may strategically take required STEM courses at community colleges to fulfill a requirement without any impact on their GPA at their primary institution. Students at elite universities may never take a two-year college course. Directly comparing the outcomes of four-year college students with and without two-year college credits is problematic because the attributes that influence their decision to take courses at a community college, such as particular motivations and academic preparedness, also affect future outcomes.

4.2 Propensity Score Matching

To mitigate selection bias, we utilize the PSM method, which is commonly used for drawing inferences in observational studies. Assuming that supplemental enrollment decisions can be estimated by observable characteristics, X_i, we can compare the outcomes of supplementally enrolled students and a simulated comparison group of students who earn no two-year credits but have a similar propensity to supplementally enroll conditional on pre-treatment characteristics (Rosenbaum & Rubin, 1983, 1985).

PSM estimates the treatment effect on the treated; in other words, the average treatment effect is generalizable to the population that is similar to the treated individuals. Our matching process is conducted using a radius caliper with replacement. We chose radius matching instead of near-neighbor matching as it limits the range of propensity scores for matched comparison units and therefore mitigates the possibility of a bad match when the closest match is far away. Matching with replacement also ensures a higher number of available comparison units when no good match can be found. The match-specific treatment effect can be calculated as:

$$ITT = Y_i^T - (\Sigma\, Y_{ij}^C)/k \qquad (2)$$

where *i* indicates the treatment unit stratum, *j* indexes the control match within the i^{th} stratum, and 1/*k* is the number of times a certain comparison unit is repeated. The average treatment effect is the average of all the individual treatment effects.

Our model compares supplementally enrolled students (those with 1-10 two-year college credits within the first three years) to students with no two-year credits. This comparison answers our key inquiry as to whether four-year college students can strategically complete a few courses at two-year colleges to improve academic outcomes, measured in terms of completion rate, credits earned, STEM performance, GPA, and accumulated debt. It also examines whether there is an earnings difference between supplementally enrolled students and four-year students who accumulate no two-year college credits.

The PSM approach has two key benefits: (1) Randomization is impossible in this case, and PSM can help better address the selection bias by allowing the comparison of outcomes only among students with similar pre-treatment characteristics such as demographic, SES, and academic background characteristics; and (2) PSM produces an estimate of the average treatment effect on the treated—that is, on four-year college students with a propensity to supplementally enroll in two-year colleges. With its focus on students who are likely to take advantage of enrollment in a limited number of two-year courses, our research may have implications for institutions and policymakers by answering whether two-year courses can be a valuable complement to a four-year education.

4.3 Implementation

The validity of PSM estimates relies on the selection-on-observables assumption, which, for our purposes, is the ability to model the selection in supplemental enrollment decisions using observable characteristics. While it is impossible to prove this assumption in any kind of PSM study, the ELS data provide a list of comprehensive measures for demographic, geographic, academic, and motivational factors that are suspected to highly correlate with selection and outcomes. The validity test of our assumption and our robustness checks indicate that our model can reasonably reduce the selection bias and reach a more causal estimation than the ordinary least square approach.

The first step of our PSM approach is to calculate the propensity to supplementally enroll among initial four-year college starters with a logistic regression:

$$Pr\ (supp = 1) = \Phi\ (X'\beta) \tag{3}$$

In equation 3, Φ is the cumulative distribution function of a standard normal distribution. X is the vector of student characteristics, including more than 30 variables pertaining to student demographic characteristics (gender, race/ethnicity, access to two-year colleges, number of siblings, SES, English language learner status, urbanicity, and region fixed effect); pre-treatment academic measures (high school GPA, participation in extra-curricular activities, admission test scores, college aspirations, financial aid offers, credits and earned and GPA in the first term, and sector and selectivity of initial four-year institution); and employment information (employment and earnings in 2004). For a complete list of the covariates, please see Table 3 in the results section. In choosing predictors, we follow Stuart's (2010) liberal inclusion approach by including as many variables as possible given the high penalty for omitting an important predictor and the low cost of including something irrelevant.

After obtaining the propensity scores, the next step is to form matches between each observation in the treatment group and observations in the counterfactual group. We use a radius caliper of 0.05 with replacement and exclude any observations without common support.[7] We use the default standard error calculated by PSMATCH2, which does not account for the fact that the propensity score is estimated. As explained below, our findings are robust to alternative computation of standard error, specifications, matching technique, and the inclusion of survey weights.

The final step is to run a regression (equation 1) comparing only students within the matched group. We examine outcomes such as total credits earned, STEM credits earned, highest degree earned, STEM-related four-year completion rate, loan accumulation, employment rate, and earnings in 2011 and 2012, which are the seventh and eighth year from initial college entry for most individuals in the sample. We also conduct subgroup analysis by gender, SES, and race/ethnicity, as the literature indicates that low-income and minoritized students tend to have weaker postsecondary outcomes (Carnevale & Rose, 2003; Jackson & Reynolds, 2013; Walpole, 2003).

5. Analysis and Results

5.1 Calculating Propensity Scores: Selection Into Supplemental Enrollment

First, we present evidence on the direction and extent of selection into supplemental enrollment among four-year college students. Table 3 presents the logistic regression results when calculating the propensity scores, displayed in terms of odds ratios.[8] It shows the correlation between various individual characteristics and earning 1 to 10 two-year credits versus none in the first three years, thereby modeling the selection into supplemental enrollment.

Consistent with Table 1, Table 3 shows that women and Asian students tended to supplementally enroll. Since distance might add time and monetary cost to taking four-year courses, individuals who lived farther away from their initial four-year colleges also

[7] This caliper setting imposes limits on the match of a comparison unit within +/- 0.025 of the treatment group's propensity scores. While some research shows that a caliper of 0.25 is sufficient to remove 98% of bias (Caliendo & Kopeinig, 2008; Cochran & Rubin, 1973), a tighter caliper is preferred to produce a close match for efficiency given that there is still sufficient overlap between the two groups.

[8] Most of the covariates are included in all the PSM models. To increase the match quality for a particular model, some variables are transformed from categorical variables to dummy variables or are estimated using a natural logarithm scale. Other times, interaction terms or squared terms are included.

Table 3
Logistic Regression Analysis: Selection Into Supplemental Enrollment

Variables	Logit: P (Earned 1 to 10 Two-Year Credits / Earned 0 Two-Year Credits)	
Female	0.360***	(0.109)
Black	0.034	(0.234)
Hispanic	-0.009	(0.220)
Asian	0.374*	(0.199)
Other race/ethnicity	0.221	(0.260)
Age at enrollment	2.075	(5.699)
Age squared	-0.061	(0.154)
Missing age	-0.217	(1.100)
Miles to initial four-year	0.034***	(0.010)
Miles to closest two-year	-0.021	(0.013)
Miles to four-year squared	-0.000**	(0.000)
Miles to two-year squared	-0.000	(0.000)
Father is high school grad only	0.373	(0.480)
Father with some college education	0.167	(0.277)
Father with at least bachelor's degree	-0.259	(0.234)
Mother is high school grad only	-0.365	(0.427)
Mother with some college education	0.086	(0.234)
Mother with at least bachelor's degree	0.117	(0.211)
Mother's education (categorical)	-0.020	(0.093)
Father's education (categorical)	0.048	(0.105)
HS GPA (3.5–4.0)	-0.031	(0.236)
HS GPA (3.0–3.4)	0.046	(0.236)
HS GPA (2.5–2.9)	-0.105	(0.224)
Delayed college enrollment	1.686***	(0.585)
Months of delay	-0.286***	(0.090)
First institution is highly selective	-0.411***	(0.142)
First institution is public institution	0.369***	(0.129)
SES quintile (categorical)	1.237***	(0.086)
SES quintile: Second lowest	-1.373***	(0.265)
SES quintile: Second highest	-2.545***	(0.351)
SES quintile: Highest	-3.552***	(0.465)
Region: Northeast	-0.377*	(0.211)
Region: South	-0.578***	(0.191)
Region: West	0.157	(0.197)
First institution is in urban area	0.296	(0.243)
First institution is in suburban area	0.451**	(0.208)
High school sector	-0.006	(0.160)
Offered grant at first institution	-0.022	(0.103)
Offered loan at first institution	0.078	(0.104)
Four-year credits earned in first term	-0.006	(0.013)
Four-year GPA earned in first term	0.020	(0.098)
Observations	3,940	

Note. Odds ratios are reported. Standard errors, clustered at the first institution level, are in parentheses. Unweighted sample sizes are rounded to the nearest 10.

*p < .1. **p < .05. ***p < .01.

tended to earn two-year credits. None of the estimates for high school or college performance were statistically significant, suggesting that the selection has little to do with individual ability. Other characteristics—such as delaying college enrollment, attending a less selective college or a public institution, coming from a low-SES background, and starting at an institution in a suburban area—all seemed to increase an individual's likelihood to supplementally enroll. Of all the variables, delayed college enrollment and SES were the strongest determinants of supplemental enrollment. These results may point to the importance of time and monetary resources in the decision to supplementally enroll.

5.2 Match Quality: Common Support and Sample Balance

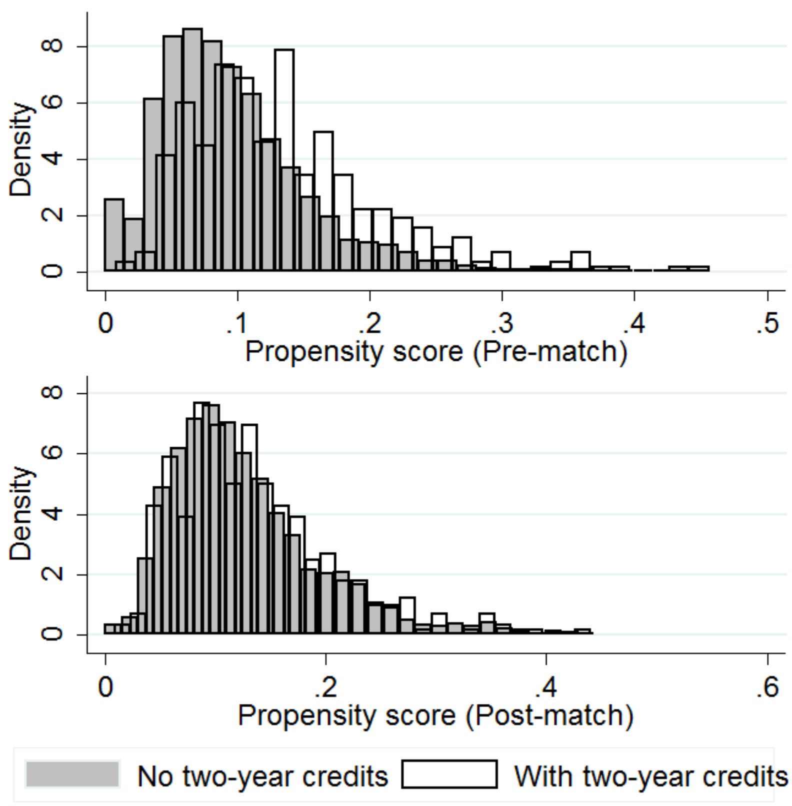
The key assumptions behind the PSM model are common support across propensity scores and balance of covariates across treatment and control groups in the final sample. The common support assumption states that there should be a positive possibility of being both treated and untreated for a substantial range of propensity scores. For example, if there are matches only at the lowest propensity scores, the final stage regression cannot be conducted among those with high propensity scores, and vice versa (Rosenbaum & Rubin, 1983). Figure 2 provides evidence upholding the common support assumption. It presents the distribution of the treated group and comparison group by the estimated propensity scores before and after matching. While there was already substantial overlap prior to matching, the distribution looks even more similar after matching. Fewer than five treated observations were off-support and dropped in each case.

The second assumption involves checking the match quality of PSM. After matching, characteristics across treatment and comparison groups should be well-balanced. Figure 3 displays the match quality by plotting the standardized percentage bias across all covariates used in matching. The larger the percentage, the higher the difference is for each particular variable. Each row represents a variable. The solid circles represent the bias of the unmatched sample and the x's represent the bias of the matched sample. The pre-matched sample had up to a 20% bias in absolute value. After matching, the standardized percentage biases of all covariates were reduced to less than 5%

(illustrated with the red line). Based on the standard used in Caliendo and Kopeinig (2008), these models are judged to be well-balanced.[9]

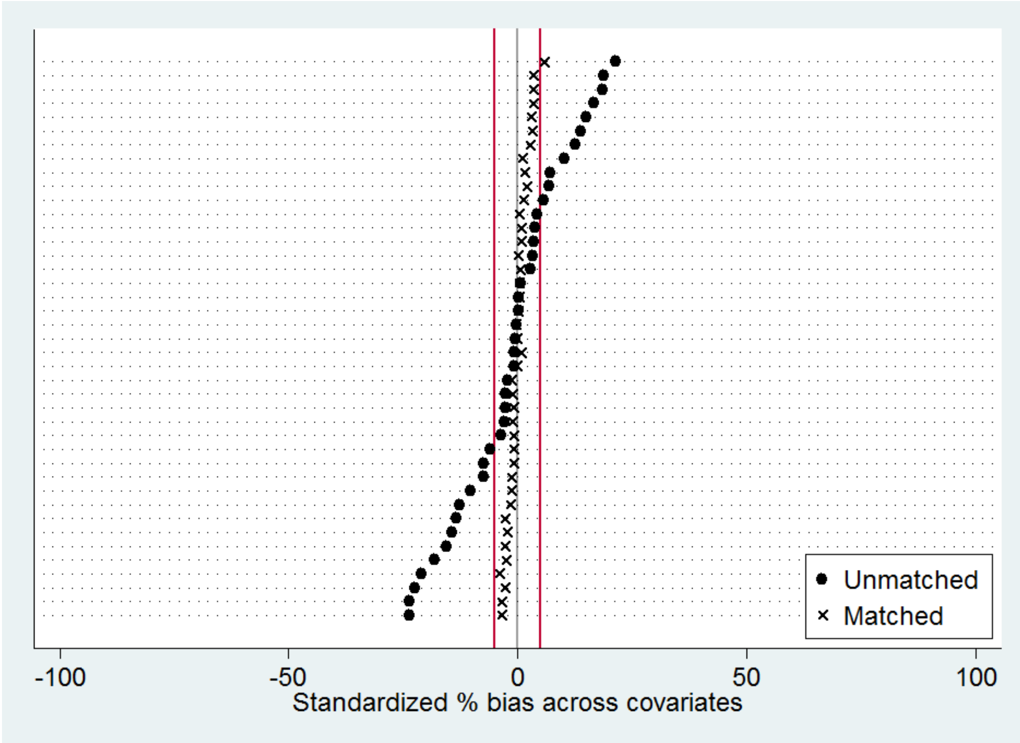
It is possible that there may still be remaining bias after our match since the selection-on-observables assumption is impossible to prove in a PSM study. We apply techniques used in research papers that employ the PSM strategy and best practices from the PSM methodology literature. All the validity checks look plausible and suggest that this approach is reasonable for our research question.

Figure 2
Pre- and Post-Match Propensity Score



[9] Details of the balance check are in Appendix Table A1.

Figure 3
Balance Check



5.3 Main Results

Table 4 presents the main PSM results comparing supplementally enrolled students to students who did not earn any two-year credits in the first three years after entering college. Relative to four-year students who earned no two-year credits, supplementally enrolled students accumulated 4.4 more credits in total. The additional credits were from two-year institutions and mostly in STEM fields. Regarding degree completion, supplementally enrolled students had a 4.5 percentage point higher bachelor's degree completion rate and a 4.4 percentage point higher graduate degree completion rate by 2012. These results indicate that two-year college course-taking has distinct features that perhaps boost the confidence of or make it easier for four-year students to succeed in their STEM courses and overall degrees. There is no statistically significant relationship between supplemental enrollment and STEM-related four-year degree attainment in the overall sample. Despite more credits earned and a higher likelihood of graduating, the difference in total loans taken out by supplementally enrolled students and students without any two-year credits was not statistically significant.

Table 4
PSM Results of Supplemental Enrollment on Academic and Employment Outcomes

Outcomes	B	*SE*
Total credits	4.369**	(2.040)
Two-year credits	7.421***	(0.568)
Four-year credits	-2.938	(2.038)
Two-year STEM credits	4.022***	(0.340)
Four-year STEM credits	1.208	(1.913)
Four-year GPA	0.006	(0.017)
No college degree by 2012	-0.019	(0.019)
Highest degree by 2012: bachelor's degree or above	0.045**	(0.018)
STEM-related bachelor's	0.027	(0.025)
Ever earned a graduate degree	0.044**	(0.021)
Undergraduate and graduated loan debt by 2012 ($)	2,264	(2,107)
Hourly wage in 2011–12 ($)	1.404***	(0.538)
Annual earnings 2011–12 ($)	1,267	(1,194)
Full time employed 2012	0.018	(0.023)
Work hours 2011–12	-0.674	(0.992)
Job satisfaction: usefulness of degree	0.050**	(0.024)
Job satisfaction: family-work balance	0.047**	(0.022)
Job satisfaction: leisure	0.032	(0.024)
N (unweighted rounded to the nearest 10)	3,950	

Note. This table presents the PSM results of the model comparing students with 1 to 10 two-year credits to students with no two-year credits. No weights. Source: ELS 02/12 Restricted-Use Data File.

Due to the higher four-year completion rate, the employment results are more also positive for supplementally enrolled students. With higher bachelor's and graduate degree attainment, supplementally enrolled students earned $1.40 more per hour than four-year students with no two-year credits in their first three years. They were also more satisfied with family-work life balance and rated the usefulness of their college education more highly than students who earned no two-year credits.

5.4 Subgroup Analysis Results

Table 4 shows that supplemental enrollment is associated with positive outcomes on average. Next, we examine whether the association is stronger for certain subgroups of students. Since we believe that female, Black, and Latinx students and students with lower SES were more likely to benefit from supplemental enrollment, Tables 5 to 7 present the PSM results by gender, SES, and racial/ ethnic subgroup, respectively.

Table 5 shows that, compared to female students with no two-year credits in their first three years of college, female supplementally enrolled students experienced larger gains in total credits (4.6 credits), two-year STEM credits (4.3 credits), four-year GPA (0.04), bachelor's degree completion rate (4.5 percentage points), STEM-related bachelor's degree completion rate (6.2 percentage points), and graduate degree attainment rate (5.8 percentage points). Perhaps due to the academic gains, female supplementally enrolled students also had higher hourly wages in 2011-12.

Supplemental enrollment did not result in the same positive gains for male students. Compared to male students with no two-year credits, male supplementally enrolled students earned more two-year credits (10.9 credits), but they also earned many fewer four-year credits (9.1 credits). In contrast to female supplementally enrolled students, who earned a higher number of total credits than non-supplementally enrolled women, male supplementally enrolled students seem to have substituted two-year credits for four-year credits. For male students, supplemental enrollment is associated with a bachelor's degree attainment rate that is 4.9 percentage points lower and a STEM-related bachelor's degree attainment rate that is 7.8 percentage points lower.

Next, Table 6 shows that supplemental enrollment is associated with more positive outcomes among low-SES students than among high-SES students. Compared to low-SES students with no two-year credits in the first three years of college, low-SES supplementally enrolled students earned more total credits and more STEM credits. The relative gains of supplemental enrollment in terms of bachelor's degree completion rate, STEM-related bachelor's degree completion, and graduate degree attainment also occurred only among low-SES supplementally enrolled students. Further, labor market gains associated with supplemental enrollment were more positive for low-SES students, in terms of hourly wages in 2011-12. For high-SES supplementally enrolled students, there exists a similar substitution effect to that of male students that we discussed earlier; they were more likely to replace four-year credits with two-year credits.

Table 5
PSM Results Among Gender Subgroups of Earning 1 to 10 Two-Year Credits on Academic and Employment Outcomes

Outcomes	Women		Men	
Total credits	4.581*	(2.456)	1.791	(2.980)
Two-year credits	7.590***	(0.811)	10.862***	(1.214)
Four-year credits	-2.592	(2.525)	-9.075***	(2.982)
Two-year STEM credits	4.315***	(0.546)	5.917***	(0.744)
Four-year STEM credits	3.079	(2.324)	-4.749*	(2.685)
Four-year GPA	0.043**	(0.019)	-0.054**	(0.025)
Highest degree by 2012 (in 7 or 8 years): bachelor’s degree or above	0.045**	(0.021)	-0.049*	(0.030)
Earned STEM-related bachelor’s	0.062**	(0.029)	-0.078**	(0.033)
Ever earned a graduate degree	0.058**	(0.025)	-0.005	(0.027)
Undergraduate and graduated loans by 2012	3,047	(2,323)	-2,094	(2,854)
Hourly wage in 2011–12	1.788***	(0.580)	1.190	(0.910)
Earnings 2011–12	874	(1,288)	1,981	(2,008)
Full time employed 2012	-0.009	(0.028)	0.020	(0.033)
Work hours 2011–12	-1.895*	(1.109)	0.883	(1.491)
Job satisfaction: usefulness of degree	0.012	(0.027)	0.076**	(0.036)
Job satisfaction: family-work balance	0.026	(0.025)	0.065**	(0.033)
Job satisfaction: leisure	-0.010	(0.028)	0.051	(0.035)
N (unweighted rounded to the nearest 10)	2,360		1,820	

Note. This table presents the PSM results of the model comparing students with 1 to 10 two-year credits to students with no two-year credits when matched and estimated within gender. Two treated observations are off-support and are dropped from the sample of women. No weights. Source: ELS 02/12 Restricted-Use Data File.

*p < .1. **p < .05. ***p < .01.

Table 6
PSM Results Among SES Subgroups of Earning 1 to 10 Two-Year Credits on Academic and Employment Outcomes

Outcomes	Low SES		High SES	
Total credits	9.782**	(4.037)	0.902	(2.073)
Two-year credits	7.381***	(1.300)	8.952***	(0.818)
Four-year credits	2.753	(4.094)	-7.939***	(2.173)
Two-year STEM credits	4.453***	(0.820)	4.986***	(0.536)
Four-year STEM credits	7.933**	(3.441)	-2.295	(2.012)
Four-year GPA	0.006	(0.034)	0.012	(0.018)
Highest degree by 2012 (in 7 or 8 years): bachelor's degree or above	0.065*	(0.034)	-0.010	(0.020)
Earned STEM-related bachelor's	0.114***	(0.041)	-0.020	(0.026)
Ever earned a graduate degree	0.077**	(0.034)	0.030	(0.022)
Undergraduate and graduate loans by 2012	2,981	(3,845)	417	(2,033)
Hourly wage in 2011–12	2.317**	(0.967)	1.437**	(0.578)
Earnings 2011–12	1,286	(1,986)	1,120	(1,306)
Full time employed 2012	0.006	(0.042)	0.002	(0.025)
Work hours 2011	-1.030	(1.765)	-0.756	(1.046)
Job satisfaction: usefulness of degree	0.070	(0.044)	0.034	(0.025)
Job satisfaction: family-work balance	0.053	(0.039)	0.032	(0.023)
Job satisfaction: leisure	0.005	(0.044)	0.016	(0.025)
N (unweighted rounded to the nearest 10)	1,080		3,070	

Note. This table presents the PSM results of comparing students with less than or equal to 10 two-year credits to students with no two-year credits when matched within SES. No weights. Source: ELS 02/12 Restricted-Use Data File.

*$p < .1$. **$p < .05$. ***$p < .01$.

Finally, Table 7 separates the matching analysis by race/ethnicity. We used two groups: White students and Black/Latinx students; we theorized that the latter group might gain the most from supplemental enrollment. (We combined the two minoritized subgroups to have more robust estimates with higher numbers of observations.) Both the White and Black/Latinx groups benefitted from supplemental enrollment in terms of two-year and two-year STEM credits earned. Supplementally enrolled White students earned 5.6 more total credits than non-supplementally enrolled White students but did not experience higher graduation rates. Supplementally enrolled Black and Latinx students experienced similar trending gains in terms of two-year and two-year STEM credits, but earned no more total credits than non-supplementally enrolled Black/Latinx students. Yet despite no significant effect on degree attainment, supplemental enrollment among Black/Latinx students is associated with $5,888 less in total student debt. This relationship between supplemental enrollment and borrowing is not found among supplementally enrolled White students. Given the similar effects on degree attainment rates across the two groups and the higher credits earned among supplementally enrolled White students, it is possible that racial/ethnic minoritized students are more efficient in preventing excess credits when supplementally enrolled than White students. Supplementally enrolled minoritized students may thus accumulate less debt.

Employment gains associated with supplemental enrollment are also highest among Black/Latinx students. Compared to Black/Latinx four-year students who earned no two-year credits, those who supplementally enrolled earned $3.81 more per hour and $5,179 more annually in 2011-12. Supplementally enrolled Black/Latinx students also had an 8.6 percentage point higher full-time employment rate.

Table 7

PSM Results Among Race/Ethnicity Subgroups of Earning 1 to 10 Two-Year Credits on Academic and Employment Outcomes

Outcomes for Model 2	White		Black & Latinx	
Total credits	5.599**	(2.185)	-0.659	(5.457)
Two-year credits	8.867***	(0.896)	6.069***	(1.388)
Four-year credits	-3.200	(2.249)	-6.451	(5.681)
Two-year STEM credits	4.829***	(0.583)	3.171***	(0.797)
Four-year STEM credits	-0.174	(2.119)	1.138	(4.621)
Four-year GPA	0.021	(0.020)	-0.019	(0.035)
Highest degree by 2012: bachelor's degree or above	0.018	(0.021)	-0.002	(0.046)
Earned STEM-related bachelor's	-0.025	(0.028)	0.060	(0.055)
Ever earned a graduate degree	0.023	(0.024)	-0.004	(0.033)
Undergraduate and graduate loans by 2012	892	(2,017)	-5,888**	(2,492)
Hourly wage in 2011–12	1.444**	(0.606)	3.813***	(1.326)
Earnings 2011–12	1,186	(1,313)	5,179**	(2,301)
Full time employed 2012	-0.021	(0.026)	0.086*	(0.051)
Work hours 2011–12	-1.738*	(1.050)	0.082	(2.446)
Job satisfaction: usefulness of degree	0.032	(0.027)	-0.022	(0.054)
Job satisfaction: family-work balance	0.034	(0.024)	0.054	(0.051)
Job satisfaction: leisure	0.010	(0.027)	0.042	(0.055)
N (unweighted rounded to the nearest 10)	2,770		740	

Note. This table presents the PSM results of the conditional counterfactual matching when matched within race/ethnicity. This model compares students with less than or equal to 10 two-year credits to students with no two-year credits. The sample of Black and Latinx students has two observations that are off-support. All of the off-support observations are dropped from the matching analysis. No weights. Source: ELS 02/12 Restricted-Use Data File.

$^{*}p < .1$. $^{**}p < .05$. $^{***}p < .01$.

5.5 Robustness Checks

As robustness checks for the main results, we first estimate the standard error with the method outlined in Abadie and Imbens (2012) to take account of the fact that the propensity scores are estimated. Second, we use a caliper of 0.25 instead of 0.05 as recommended by Caliendo and Kopeinig (2008) and Cochran and Rubin (1973). Third, we employ probit instead of logit regression to estimate the propensity scores. Fourth, we run an alternative specification with the nearest neighbor matching method to test if the results are robust to different types of matching strategies. Fifth, we restrict the sample to observations with "thick support"—that is with propensity scores less than 0.60. Finally, we add survey weights to the estimation. There are small differences across these alternative specifications, but the results are generally consistent with those in Table 4.[10] For more detail, see Appendix Tables A3 and A4.

6. Summary and Conclusion

This paper explores whether earning a limited number of two-year college credits can benefit beginning four-year college students' academic, STEM, and labor market outcomes. On average, supplemental enrollment is associated with more total college credits earned, increased likelihood of bachelor's degree attainment, and higher hourly wages in the labor market—without increasing student loan debt. For student subgroups, supplemental enrollment is associated with additional benefits including earning more STEM credits, higher rates of STEM-related bachelor's degree attainment, higher rates of graduate degree attainment, and lower student loan debt.

Select, statistically significant, overall and subgroup effect sizes associated with supplemental enrollment in a community college are provided below. These effect sizes are presented in comparison to students from the same demographic groups (i.e. gender,

[10] We also used a PSM model in which the matching is conducted among students within the same initial four-year institutions. Since individuals may select four-year institutions based on unobserved characteristics, the estimates obtained from this model would tell us whether the selection into four-year institutions may bias the results. But since treatment and control observations were not presented for all four-year institutions, nearly half of the observations were dropped during the matching process.

SES, and race/ethnicity) who earned no two-year credits. Some descriptive outcomes for the entire sample of four-year college students, from Table 1, are shown in parentheses.

All Supplemental Enrollment Students

- 4.4 more total college credits earned (the average number of credits earned among the entire sample of four-year students was 111), 4.0 of which were STEM credits earned in community colleges.
- 4.5 percentage point higher rate of bachelor's degree completion (the average rate of bachelor's degree completion among the entire sample was 62%).
- $1.40 higher hourly wages (the average hourly wage among the entire sample was $19 per hour).

Female Supplemental Enrollment Students

- 4.6 more total college credits earned, 4.3 of which were STEM credits earned in community colleges.
- 0.043 higher college GPA (the average GPA among the entire sample was 3.17)
- 4.5 percentage point higher rate of bachelor's degree completion.
- 6.2 percentage point higher rate of STEM-related bachelor's degree completion (the average rate among the entire sample was 17%).
- 5.8 percentage point higher rate of graduate degree completion (the average rate among the entire sample was 26%).
- $1.79 higher hourly wages.

Supplemental Enrollment Students with Low SES

- 9.8 more total college credits earned, 4.5 of which were STEM credits earned in community colleges.
- 6.5 percentage point higher rate of bachelor's degree completion.
- 11 percentage point higher rate of STEM-related bachelor's degree completion.
- 7.7 percentage point higher rate of graduate degree completion.
- $2.31 higher hourly wages.

Black and Latinx Supplemental Enrollment Students

- 3.17 more STEM credits earned in community colleges.
- $5,888 less in student loans.
- $3.81 higher hourly wages.
- 8.6 percentage points more likely to be full-time employed.

Two-year colleges have long been thought to be a substitute for or a stepping stone to four-year colleges. This study finds evidence indicating the complementary quality of education at two-year and four-year colleges. The results suggest that supplemental enrollment at community colleges (earning 1 to 10 credits at these public two-year colleges) can potentially help four-year students earn more STEM credits, attain a bachelor's degree, and improve employment outcomes, without increasing their student loan debt. The positive employment gains also suggest that the labor market does not penalize four-year college students who earn some two-year credits.

The findings of the subgroup analysis we carry out have important equity implications. The results suggest that supplemental enrollment is associated with positive academic and labor market gains for low-SES and female students, and large positive labor market outcomes for non-White students, populations that tend to have weaker outcomes in higher education. Supplemental enrollment may help these subgroup students achieve higher rates of degree attainment, lower debts, and/or stronger labor force outcomes. Additionally, supplemental enrollment is positively associated with STEM-related bachelor's degree attainment for female and low-SES students, and with STEM credit accumulation for low-income students, students of color, and female students, all of whom are traditionally underrepresented in STEM.

Our findings provide empirical evidence that two-year courses may be more successful in helping female and low-income students build confidence and perform well, especially in STEM fields. Early STEM course performance is highly predictive of student's major persistence and completion (Ost, 2010). Community colleges may have qualities that are conducive to learning for underrepresented students in STEM. The availability of institutional support, presence of role models, sense of belonging in STEM courses, and existence of same-gendered peers in STEM courses likely impact success in

STEM courses (Chen & Soldner, 2013; Johnson, 2012; Smith, Lewis, & Hawthorne, 2013). And given that community colleges tend to enroll more female and low-income students (Goldrick-Rab & Pfeffer, 2009), students from these groups may feel less marginalized in STEM classrooms and experience a stronger sense of belonging.

Our main analysis finds that almost one in five of all four-year students earns credits from a community college. Given the prevalence of combining two-year and four-year education, there are steps that both two-year and four-year colleges can take to streamline the process of supplemental enrollment for students. For example, standardized course numbering across two-year and four-year colleges and clear policies on transferrable credits are vital to preventing credit loss and creating an efficient supplemental enrollment experience.

There is also a need for more research on this topic. As four-year students continue to enroll in community colleges, researchers should look at whether supplementally enrolled students crowd out the resources of other community college students and whether supplemental enrollment serves to shift costs from students to taxpayers, as community colleges are heavily funded by the government. How supplemental enrollment facilitates stronger course performance in STEM coursework among traditionally underrepresented students is another area for future research.

References

Abadie, A., & Imbens, G. W. (2012). A martingale representation for matching estimators. *Journal of the American Statistical Association, 107*(498), 833–843.

Adelman, C. (1999). *Answers in the tool box: Academic intensity, attendance patterns, and bachelor's degree attainment.* Washington, DC: U.S. Department of Education, Office of Educational Research Improvement.

Adelman, C. (2005). *Moving into town—and moving on: The community college in the lives of traditional-age students.* Washington, DC: U.S. Department of Education.

Alfonso, M. (2006). The impact of community college attendance on baccalaureate attainment. *Research in Higher Education*, *47*(8), 873–903.

Andrews, R., Li, J., & Lovenheim, M. F. (2014). Heterogeneous paths through college: Detailed patterns and relationships with graduation and earnings. *Economics of Education Review*, *42*, 93–108.

Arcidiacono, P., Aucejo, E. M., & Hotz, V. J. (2015). University differences in the graduation minorities in STEM fields: evidence from California. *American Economic Review*, *106*(3), 535–62.

Arcidiacono, P., Aucejo, E. M., and Spenner, K. (2012). What happens after enrollment? An analysis of the time path of racial differences in GPA and major choice. *IZA Journal of Labor Economics*, *1*(1), 1–24. http://doi.org/10.1186/2193-8997-1-5

Austin, P. C. (2008). A critical appraisal of propensity-score matching in the medical literature between 1996 and 2003. *Statistics in Medicine*, *27*(12), 2037–2049.

Baum, S., Ma, J., Pender, M., & Welch, M. (2017). *Trends in student aid 2017* (A Trends in Higher Education Series Paper). New York, NY: The College Board. Retrieved from https://trends.collegeboard.org/sites/default/files/2017-trends-student-aid_0.pdf

Barr, D. A., Gonzalez, M. E., & Wanat, S. F. (2008). The leaky pipeline: Factors associated with early decline in interest in premedical studies among underrepresented minority undergraduate students. *Academic Medicine, 83*(5), 503–511.

Basken, P. (2010, March). NSF seeks new approach to helping minority students in science. The Chronicle of Higher Education. Retrieved March 15, 2019 from http://chronicale .com/article/NSF-Seeks-New-Approach-to/64592.

Becker, G. S. (1962). Investment in human capital: A theoretical analysis. *Journal of Political Economy, 70*(5), 9–49.

Behrman, J. R., & Birdsall, N. (1983). The quality of schooling: Quantity alone is misleading. *The American Economic Review, 73*(5), 928–946.

Brint, S., & Karabel, J. (1989). *The diverted dream: Community colleges and the promise of educational opportunity in America, 1900–1985*. New York, NY: Oxford University Press.

Caliendo, M., & Kopeinig, S. (2008). Some practical guidance for the implementation of propensity score matching. *Journal of Economic Surveys*, *22*(1), 31–72.

Card, D. (1995). Using geographic variation in college proximity to estimate the return to schooling. In L. N. Christofides, E. K. Grant, & R. Swidinsky (Eds.), *Aspects of labor market behavior: Essays in honour of John Vanderkamp*. Toronto, Canada: University of Toronto Press.

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of research in science teaching*, *44*(8), 1187–1218.

Carnevale, A. P., & Rose, S. J. (2003*). Socioeconomic status, race/ethnicity, and selective college admissions* (A Century Foundation Paper). Retrieved from https://files.eric.ed.gov/fulltext/ED482419.pdf

Catanzaro, J. L. (1999). Understanding and recruiting the reverse transfer student: A presidential perspective. *New Directions for Community Colleges*, *1999*(106), 27–34.

Chen, X. (2009). *Students who study science, technology, engineering, and mathematics (STEM) in postsecondary education. Stats in brief* (NCES 2009-161). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Chen, X., & Soldner, M. (2013). *STEM attrition: College students' paths into and out of STEM fields* (NCES 2014-001). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Clark, B. R. (1960). The "cooling-out" function in higher education. *American Journal of Sociology*, *65*(6), 569–576.

Clark, B. R. (1980). The "cooling out" function revisited. *New Directions for Community Colleges*, *1980*(32), 15–31.

Cochran, W. G., & Rubin, D. B. (1973). Controlling bias in observational studies: A review. *Sankhya: The Indian Journal of Statistics, Series A, 35*(4), 417–446.

de los Santos, Jr., A. G., & Sutton, F. (2012). Swirling students: Articulation between a major community college district and a state-supported research university. *Community College Journal of Research and Practice*, *36*(12), 967–981.

Dowd, A. C., Cheslock, J. J., & Melguizo, T. (2008). Transfer access from community colleges and the distribution of elite higher education. *The Journal of Higher Education*, *79*(4), 442-472.

Dynan, K. E., & Rouse, C. E. (1997). The Underrepresentation of Women in Economics: A Study of Undergraduate Economics Students. *The Journal of Economic Education*, *28*(4), 350–368. http://doi.org/10.1080/00220489709597939

Eagan, K., Hurtado, S., & Chang, M. (2010, October). *What matters in STEM: Institutional contexts that influence STEM bachelor's degree completion rates.* Paper presented at the annual meeting of the Association for the Study of Higher Education, Indianapolis, IN.

Friedl, J., Pittenger, D., & Sherman, M. (2012). Grading standards and student performance in community college and university courses. *College Student Journal*, *46*(3), 526–532.

Griffith, A. L. (2010). Persistence of women and minorities in STEM field majors: Is it the school that matters? *Economics of Education Review*, *29*(6), 911–922.

Goldhaber, D., Gross, B., & DeBurgomaster, S. (2008). *Community colleges and higher education: How do state transfer and articulation policies impact student pathways?* (CRPE Working Paper 2008-4). Seattle, WA: University of Washington, Center on Reinventing Public Education. Retrieved from https://files.eric.ed.gov/fulltext/ED504666.pdf

Goldrick-Rab, S., & Pfeffer, F. T. (2009). Beyond access: Explaining socioeconomic differences in college transfer. *Sociology of Education*, *82*(2), 101–125.

Gross, B., & Goldhaber, D. (2009). *Community college transfer and articulation policies: Looking beneath the surface* (CRPE Working Paper 2009-1). Seattle: WA: University of Washington, Center on Reinventing Public Education. Retrieved from https://files.eric.ed.gov/fulltext/ED504665.pdf

Hagedorn, L. S., & Castro, C. R. (1999). Paradoxes: California's experience with reverse transfer students. *New Directions for Community Colleges*, *1999*(106), 15–26.

Hurtado, S., Newman, C. B., Tran, M. C., & Chang, M. J. (2010). Improving the rate of success for underrepresented racial minorities in STEM fields: Insights from a national project. *New Directions for Institutional Research*, *2010*(148), 5–15.

Jackson, B. A., & Reynolds, J. R. (2013). The price of opportunity: Race, student loan debt, and college achievement. *Sociological Inquiry*, *83*(3), 335–368.

Johnson, D. R. (2012). Campus racial climate perceptions and overall sense of belonging among racially diverse women in STEM majors. *Journal of College Student Development*, *53*(2), 336–346.

Johnson, V. E. (2003). *Grade inflation: A crisis in college education*. Springer Science & Business Media.

Kalogrides, D., & Grodsky, E. (2011). Something to fall back on: Community colleges as a safety net. *Social Forces*, *89*(3), 853–877.

Liu, V. Y. T. (2016). *Do students benefit from going backward? The academic and labor market consequences of four-to two-year college transfer* (CAPSEE Working Paper). New York, NY: Center for Analysis of Postsecondary Education and Employment.

Ma, J., Baum, S., Pender, M., & Bell, D. W. (2015). *Trends in college pricing 2015* (Trends in Higher Education Series Report). New York, NY: The College Board. Retrieved from https://trends.collegeboard.org/sites/default/files/2015-trends-college-pricing-final-508.pdf

Ma, J., Baum, S., Pender, M., & Libassi, C .J. (2019). *Trends in college pricing 2019* (Trends in Higher Education Series Report). New York, NY: The College Board. Retrieved from https://research.collegeboard.org/pdf/trends-college-pricing-2019-full-report.pdf

McCormick, A. C. (2003). Swirling and double-dipping: New patterns of student attendance and their implications for higher education. *New Directions for Higher Education*, *2003*(121), 13–24.

Moldoff, D. K. (2006). *How does college transfer and the course credit assessment process work?* Retrieved from https://www.collegetransfer.net/AskCT/Howdoesthecoursecredittransferprocesswork/tabid/2411/default.aspx

Monaghan, D. B., & Attewell, P. (2015). The community college route to the bachelor's degree. *Educational Evaluation and Policy Analysis*, *37*(1), 70–91.

Mooney, G. M., & Foley, D. J. (2011). *Community colleges: Playing an important role in the education of science, engineering, and health graduates* (NCSES Info Brief). Washington, DC: National Center for Science and Engineering Statistics. Retrieved from https://wayback.archive-it.org/5902/20180608220955/https://www.nsf.gov/statistics/infbrief/nsf11317/nsf11317.pdf

Ost, B. (2010). *Differences in persistence patterns between life and physical science majors: the role of grades, peers, and preparation.* (Cornell University ILR School Working Paper). Retrieved from http://digitalcommons.ilr.cornell.edu/workingpapers/119

Owen, A. L. (2008). *Grades, gender, and encouragement: A regression discontinuity analysis* (MPRA Paper). Munich Personal RePEc Archive. Retrieved from http://mpra.ub.uni-muenchen.de/11586/

Rask, K. (2010). Attrition in STEM fields at a liberal arts college: The importance of grades and pre-collegiate preferences. *Economics of Education Review*, *29*(6), 892–900.

Rask, K., & Tiefenthaler, J. (2008). The role of grade sensitivity in explaining the gender imbalance in undergraduate economics. *Economics of Education Review*, *27*(6), 676–687. http://doi.org/10.1016/j.econedurev.2007.09.010

Reyes, M. E. (2011). Unique challenges for women of color in STEM transferring from community colleges to universities. *Harvard Educational Review*, *81*(2), 241–263.

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, *70*(1), 41–55.

Rosenbaum, P. R., & Rubin, D. B. (1985). Constructing a control group using multivariate matched sampling methods that incorporate the propensity score. *The American Statistician*, *39*(1), 33–38.

Sekaquaptewa, D., & Thompson, M. (2003). Solo status, stereotype threat, and performance expectancies: Their effects on women's performance. *Journal of Experimental Social Psychology*, *39*(1), 68–74. http://doi.org/10.1016/S0022-1031(02)00508-5

Seymore, E. (1992). Undergraduate problems with teaching and advising in science, mathematics, and engineering majors: Explaining gender differences in attrition rates. *Journal of College Science Teaching*, *21*(5), 284–292.

Seymore, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview.

Smith, J. L., Lewis, K. L., Hawthorne, L., & Hodges, S. D. (2013). When trying hard isn't natural: Women's belonging with and motivation for male-dominated STEM fields as a function of effort expenditure concerns. *Personality and Social Psychology Bulletin*, *39*(2), 131–143.

Tobias, S. (1992). *Revitalizing undergraduate science: Why some things work and most don't. Tucson, AZ:* Research Corporation.

Townsend, B. K. (2008). "Feeling like a freshman again": The transfer student transition. *New Directions for Higher Education*, *2008*(144), 69–77.

Schutz, K. R., Drake, B. M., & Lessner, J. (2013). Do community college full-time and adjunct faculties differ in their perceptions of rigor in assigning grades? *American Journal of Educational Studies*, *6*(2).

Shapiro, D., Dundar, A., Huie, F., Wakhungu, P. K., Bhimdiwala, A., Nathan, A., & Youngsik, H. (2018, July). *Transfer and mobility: A national view of student movement in postsecondary institutions, Fall 2011 cohort* (Signature Report No. 15). Herndon, VA: National Student Clearinghouse Research Center. Retrieved from: https://nscresearchcenter.org/signaturereport15/

Stuart, E. A. (2010). Matching methods for causal inference: A review and a look forward. *Statistical Science: A Review Journal of the Institute of Mathematical Statistics*, *25*(1), 1–21.

Ülkü-Steiner, B., Kurtz-Costes, B., & Ryan, C. (2000). Doctoral student experiences in gender-balanced and male-dominated graduate programs. *Journal of Educational Psychology*, *92*(2), 296–307. http://doi.org/10.1037/0022-0663.92.2.296

U.S. Department of Education. (2008). *Figure CL-9. Percentage distribution of faculty in degree–granting institutions, by highest level of educational attainment, minority race/ethnicity, and control and type of institution: Fall 2003*. Washington, DC: Author. Retrieved from https://nces.ed.gov/programs/coe/analysis/figures/2008-fig9.asp?popup=true

U.S. Department of Education. (2017). *Table 316.80. Percentage of degree-granting postsecondary institutions with a tenure system and of full-time faculty with tenure at these institutions, by control and level of institution and selected characteristics of faculty: Selected years, 1993-94 through 2016-17*. Washington, DC: Author. Retrieved from https://nces.ed.gov/programs/digest/d17/tables/dt17_316.80.asp

Walpole, M. (2003). Socioeconomic status and college: How SES affects college experiences and outcomes. *The Review of Higher Education*, *27*(1), 45–73.

Xu, D., Jaggars, S. S., Fletcher, J., & Fink, J. E. (2018). Are community college transfer students “a good bet” for 4-year admissions? Comparing academic and labor-market outcomes between transfer and native 4-year college students. *The Journal of Higher Education*, *89*(4), 478–502.

Appendix

Table A1
Sample Means and Standard Differences Pre- and Post-Match

Variables	Sample	Mean		Standard Deviation		Standardized Difference	Ratio of SDs
		Treated	Control	Treated	Control		
Female	Unmatched	0.645	0.554	0.48	0.5	0.188	0.96
	Matched	0.644	0.627	0.48	0.48	0.035	0.99
Black	Unmatched	0.092	0.1	0.29	0.3	-0.027	0.97
	Matched	0.092	0.095	0.29	0.29	-0.01	0.99
Hispanic	Unmatched	0.077	0.079	0.27	0.27	-0.007	0.99
	Matched	0.077	0.075	0.27	0.26	0.009	1.02
Asian	Unmatched	0.151	0.109	0.36	0.31	0.118	1.15
	Matched	0.151	0.142	0.36	0.35	0.026	1.03
Other races/ethnicities	Unmatched	0.056	0.044	0.23	0.21	0.053	1.12
	Matched	0.056	0.054	0.23	0.23	0.012	1.02
Age at enrollment	Unmatched	18.306	18.483	0.5	0.93	-0.353	0.54
	Matched	18.307	18.333	0.5	0.58	-0.053	0.87
Age squared	Unmatched	335.359	342.507	18.64	38.39	-0.383	0.49
	Matched	335.388	336.444	18.65	22.21	-0.057	0.84
Missing age	Unmatched	0.003	0.003	0.05	0.05	-0.005	0.95
	Matched	0.003	0.003	0.05	0.05	-0.003	0.98
Miles to initial four-year	Unmatched	16.771	14.104	17.41	14.77	0.153	1.18
	Matched	16.66	16.124	17.3	16.64	0.031	1.04
Miles to closest two-year	Unmatched	9.885	11.444	9.21	12.41	-0.169	0.74
	Matched	9.899	10.141	9.22	9.65	-0.026	0.96
Miles to four-year squared	Unmatched	583.776	417.074	1271.95	1138.57	0.131	1.12
	Matched	576.065	536.674	1264.4	1314.93	0.031	0.96
Miles to two-year squared	Unmatched	182.282	284.812	377.81	1075.29	-0.271	0.35
	Matched	182.699	195.871	378.21	556.33	-0.035	0.68
Father is high school grad only	Unmatched	0.246	0.245	0.43	0.43	0.001	1
	Matched	0.246	0.245	0.43	0.43	0.002	1
Father with some college education	Unmatched	0.271	0.253	0.45	0.43	0.041	1.02
	Matched	0.269	0.268	0.44	0.44	0.003	1
Father with at least bachelor's degree	Unmatched	0.212	0.244	0.41	0.43	-0.076	0.95
	Matched	0.213	0.217	0.41	0.41	-0.01	0.99
Mother is high school grad only	Unmatched	0.205	0.248	0.4	0.43	-0.107	0.94
	Matched	0.205	0.211	0.4	0.41	-0.014	0.99
Mother with some college education	Unmatched	0.363	0.315	0.48	0.46	0.1	1.04
	Matched	0.362	0.356	0.48	0.48	0.01	1
Mother with at least bachelor's degree	Unmatched	0.161	0.161	0.37	0.37	0.002	1
	Matched	0.162	0.16	0.37	0.37	0.004	1
Mother's education (categorical)	Unmatched	4.604	4.535	1.95	1.99	0.035	0.98
	Matched	4.608	4.594	1.95	1.93	0.007	1.01
Father's education (categorical)	Unmatched	4.754	4.831	2.1	2.17	-0.036	0.97
	Matched	4.754	4.771	2.1	2.13	-0.008	0.98

HS GPA (3.5–4.0)	Unmatched	0.499	0.503	0.5	0.5	-0.008	1
	Matched	0.5	0.501	0.5	0.5	-0.003	1
HS GPA (3.0–3.4)	Unmatched	0.299	0.269	0.46	0.44	0.066	1.03
	Matched	0.297	0.289	0.46	0.45	0.019	1.01
HS GPA (2.5–2.9)	Unmatched	0.136	0.146	0.34	0.35	-0.029	0.97
	Matched	0.136	0.14	0.34	0.35	-0.012	0.99
Delayed college enrollment	Unmatched	0.023	0.059	0.15	0.24	-0.238	0.64
	Matched	0.023	0.028	0.15	0.16	-0.032	0.91
Months of delay	Unmatched	2.309	3.657	1.13	8.42	-1.188	0.13
	Matched	2.31	2.479	1.14	3.13	-0.149	0.36
First institution is highly selective	Unmatched	0.297	0.37	0.46	0.48	-0.16	0.95
	Matched	0.297	0.311	0.46	0.46	-0.029	0.99
First institution is public institution	Unmatched	0.729	0.642	0.45	0.48	0.195	0.93
	Matched	0.728	0.713	0.45	0.45	0.035	0.98
SES quintile (categorical)	Unmatched	3.13	3.097	1.02	1.07	0.033	0.95
	Matched	3.131	3.129	1.02	1.02	0.002	1
SES quintile: Second lowest	Unmatched	0.148	0.158	0.36	0.37	-0.028	0.97
	Matched	0.149	0.152	0.36	0.36	-0.008	0.99
SES quintile: Second highest	Unmatched	0.258	0.26	0.44	0.44	-0.004	1
	Matched	0.256	0.259	0.44	0.44	-0.005	1
SES quintile: Highest	Unmatched	0.488	0.475	0.5	0.5	0.027	1
	Matched	0.49	0.487	0.5	0.5	0.005	1
Region: Northeast	Unmatched	0.138	0.187	0.35	0.39	-0.143	0.89
	Matched	0.138	0.148	0.35	0.36	-0.029	0.97
Region: South	Unmatched	0.286	0.385	0.45	0.49	-0.217	0.93
	Matched	0.287	0.305	0.45	0.46	-0.04	0.98
Region: West	Unmatched	0.243	0.158	0.43	0.36	0.198	1.18
	Matched	0.244	0.221	0.43	0.41	0.053	1.04
First institution is in urban area	Unmatched	0.348	0.384	0.48	0.49	-0.077	0.98
	Matched	0.349	0.355	0.48	0.48	-0.014	1
First institution is in suburban area	Unmatched	0.532	0.458	0.5	0.5	0.149	1
	Matched	0.531	0.516	0.5	0.5	0.03	1
HS sector	Unmatched	0.322	0.35	0.47	0.48	-0.06	0.98
	Matched	0.323	0.328	0.47	0.47	-0.009	1
Offered grant in first institution	Unmatched	0.338	0.306	0.8	0.83	0.039	0.96
	Matched	0.338	0.332	0.8	0.81	0.008	0.98
Offered loan in first institution	Unmatched	0.263	0.208	0.78	0.8	0.071	0.97
	Matched	0.264	0.253	0.78	0.79	0.014	0.98
Four-year credits earned in first term	Unmatched	12.68	12.775	3.7	4.43	-0.026	0.83
	Matched	12.674	12.728	3.7	4.22	-0.015	0.88
Four-year GPA earned in first term	Unmatched	3.096	3.092	0.62	0.61	0.007	1.02
	Matched	3.096	3.093	0.63	0.62	0.004	1.01

Note. Std. Diff. = standardized difference in group means, calculated following the formula by Austin (2008). The ratio of SD is the ratio of the standard deviation between the supplemental enrollment and no two-year credits samples, calculated by dividing the higher standard deviation by the standard deviation of the other group.

*p < .1. **p < .05. ***p < .01.

Table A2
OLS Results of Earning Two-Year Credits on Academic and Employment Outcomes, Overall and by Counterfactual

Outcomes	B	*SE*
Total credits	4.096**	(2.079)
Two-year credits	7.719***	(0.574)
Four-year credits	-3.478*	(2.090)
Two-year STEM credits	4.355***	(0.349)
Four-year STEM credits	1.556	(1.942)
Four-year GPA	-0.001	(0.018)
Highest degree by 2012: bachelor's degree or above	0.046**	(0.018)
Ever earned a graduate degree	0.041*	(0.021)
Undergraduate loans by 2012	-1,416**	(683)
Hourly wage in 2011–12	1.462***	(0.542)
Earnings 2011–12	1,318	(1,193)
Full time employed 2012	0.025	(0.023)
Work hours 2011–12	-0.709	(1.003)
Job satisfaction: earnings	0.020	(0.026)
Job satisfaction: usefulness of degree	0.054**	(0.024)
Job satisfaction: family-work balance	0.043*	(0.022)
N (unweighted rounded to the nearest 10)	3,950	

Note. This table presents the ordinary least square regression results. The coefficients indicate the differences in outcomes comparing students with less than or equal to 12 two-year credits to students with no two-year credits. No weights. Source: ELS 02/12 Restricted-Use Data File.

*$p < .1$. **$p < .05$. ***$p < .01$.

Table A3
Robustness Check Using Different Standard Error, Caliper, and Propensity Score Calculation

Outcomes	Abadie & Imbens Standard Error		Caliper 0.25		Probit Used in Propensity Score Calculation	
	B	*SE*	B	*SE*	B	*SE*
Total credits	5.936*	(3.284)	3.553*	(2.036)	4.721**	(2.019)
Two-year credits	7.504***	(0.820)	7.602***	(0.552)	7.796***	(0.557)
Four-year credits	-1.093	(3.352)	-3.957*	(2.019)	-2.867	(2.025)
Two-year STEM credits	4.020***	(0.542)	4.210***	(0.333)	4.383***	(0.343)
Four-year STEM credits	3.334	(2.899)	0.899	(1.886)	1.851	(1.896)
Four-year GPA	0.036	(0.038)	-0.012	(0.017)	0.002	(0.017)
No college degree by 2012	-0.022	(0.030)	-0.022	(0.018)	-0.019	(0.019)
Highest degree by 2012: associate degree	-0.027**	(0.011)	-0.025***	(0.005)	-0.023***	(0.006)
Highest degree by 2012: bachelor's degree or above	0.054*	(0.029)	0.041**	(0.018)	0.046***	(0.018)
Ever earned a graduate degree	0.015	(0.032)	0.026	(0.021)	0.042**	(0.021)
Undergraduate/graduate loans by 2012	2,296	(3,024)	942.1	(2,003)	2,593	(2,081)
Hourly wage in 2011–12	1.619**	(0.776)	1.292**	(0.534)	1.413***	(0.529)
Earnings 2011–12	3,177*	(1,700)	1,542	(1,208)	1,244	(1,174)
Full time employed 2012	0.067**	(0.032)	0.030	(0.023)	0.021	(0.023)
Work hours 2011–12	0.998	(1.377)	-0.018	(0.112)	-0.038	(0.107)
Job satisfaction: usefulness of degree	0.069**	(0.033)	0.048*	(0.024)	0.052**	(0.024)
Job satisfaction: family-work balance	0.030	(0.031)	0.043*	(0.022)	0.042*	(0.022)
Job satisfaction: leisure	0.042	(0.033)	0.028	(0.024)	0.027	(0.024)
N (unweighted N rounded to the nearest 10)	3,950		3,950		3,950	

Note. No weights. Source: ELS 02/12 Restricted-Use Data File.

*$p < .1$. **$p < .05$. ***$p < .01$.

Table A4

Robustness Check Using Nearest Neighbor Matching, Thick Support Observation, and Adding Survey Weights

	Nearest Neighbor Matching		Thick Support (PS < 0.6)		Adding Survey Weights	
Outcomes	B	*SE*	B	*SE*	B	*SE*
Total credits	6.963**	(2.903)	4.571**	(2.029)	3.476	(2.318)
Two-year credits	7.216***	(0.812)	7.708***	(0.561)	6.697***	(0.565)
Four-year credits	0.242	(2.934)	-3.069	(2.029)	-2.793	(2.379)
Two-year STEM credits	3.847***	(0.551)	4.312***	(0.345)	3.810***	(0.359)
Four-year STEM credits	3.796	(2.652)	1.691	(1.898)	0.015	(2.132)
Four-year GPA	0.024	(0.025)	-0.001	(0.017)	0.009	(0.023)
No college degree by 2012	-0.024	(0.027)	-0.020	(0.019)	-0.047**	(0.023)
Highest degree by 2012: associate degree	-0.029***	(0.011)	-0.023***	(0.006)	-0.024***	(0.007)
Highest degree by 2012: bachelor's degree or above	0.060**	(0.026)	0.046***	(0.018)	0.055**	(0.022)
Ever earned a graduate degree	0.017	(0.030)	0.041*	(0.021)	0.054**	(0.026)
Undergraduate/graduate loans by 2012	2,623	(2,819)	2,593	(2,086)	2,991	(2,420)
Hourly wage in 2011–12	1.727**	(0.731)	1.438***	(0.530)	1.465**	(0.741)
Earnings 2011–12	2,921.102*	(1,696)	1,306	(1,178)	-258	(1,506)
Full time employed 2012	0.081**	(0.033)	0.023	(0.023)	-0.026	(0.030)
Work hours 2011–12	0.182	(0.162)	0.001	(0.105)	-0.160	(0.143)
Job satisfaction: usefulness of degree	0.078**	(0.034)	0.055**	(0.024)	0.038	(0.031)
Job satisfaction: family-work balance	0.041	(0.031)	0.045**	(0.022)	0.048*	(0.026)
Job satisfaction: leisure	0.041	(0.034)	0.029	(0.024)	0.013	-0.03
N (unweighted N rounded to the nearest 10)	733		3,950		3,566	

Note. No weights. Source: ELS 02/12 Restricted-Use Data File.

**p* < .1. ***p* < .05. ****p* < .01.