

THE COSTS AND BENEFITS OF EARLY COLLEGE HIGH SCHOOLS

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Abstract

Early colleges (ECs) provide high school students access to college coursework with the goal of increasing postsecondary opportunities for traditionally underrepresented students. We examine the impact of ECs on postsecondary attainment, calculate the resulting monetary benefits, and then estimate the per-student costs of ECs compared with traditional high schools to assess costs and benefits. Our findings indicate that students enrolling in ECs in our study are more likely to attend college and graduate with an associate's or bachelor's degree. Increased educational attainment from EC enrollment results in lifetime benefits of almost \$58,000 per student. ECs cost approximately \$950 more than traditional high schools per student per year, resulting in an overall cost of \$3,800 more per student across four years of high school. Comparing benefits to cost, we estimate a net present value (NPV) of \$54,000 per student and a benefit–cost ratio of 15.1. Even when using conservative estimates of costs (upper bound) and benefits (lower bound), we calculate an NPV of over \$27,000 and a benefit–cost ratio of 4.6. These results indicate that investment in ECs pays off through increased earnings for EC students, increased tax revenue, and decreased government spending.

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1. INTRODUCTION

Postsecondary credentials are increasingly needed for upward mobility in the U.S. economy (Carnevale, Rose, and Cheah 2011). Yet wide disparities in access to higher education exist between low-income students and students of color and their more advantaged peers (Bailey and Dynarski 2011; Duncheon 2015, 2018). Early colleges (ECs) represent an expanding college readiness reform that provides students an opportunity to earn up to sixty college credits in high school through dual-enrollment coursework. ECs are intended to target students who are historically underrepresented in postsecondary education and provide additional resources in the form of college advising, summer bridge programs, and other academic supports. Although ECs may increase college enrollment and completion, policy makers currently do not have sufficient evidence to determine whether the benefits are large enough to warrant the costs.

Since the inception of the Early College High School Initiative (ECHSI) in 2002, numerous studies have examined student outcomes related to enrollment in ECs, including several with strong causal inference. Between 2010 and 2013, the American Institutes for Research (AIR) conducted an evaluation of ten ECs across the United States that used admission lotteries to examine college enrollment and short-term degree attainment outcomes (Haxton et al. 2016). In a follow-up study, AIR examined postsecondary outcomes six years after expected high school graduation (Song and Zeiser 2019). The SERVE Center at the University of North Carolina at Greensboro conducted a similar study of ECs that used lottery-based admission in North Carolina (Edmunds et al. 2017). These studies found positive impacts of ECs on a variety of student outcomes, including high school graduation, college enrollment, and college degree attainment.

Although positive outcomes for students are evident, little research has assessed the cost of ECs compared with a traditional high school education. In addition to merely understanding whether educational interventions are effective, policy makers need to understand whether interventions are efficient (Levin et al. 2018). Only by understanding efficiency can we make statements about whether a given intervention is a better use of resources than an alternative or, more generally, is worth the investment of resources necessary for implementation.

The Early College Model

The ECHSI was established in 2002 by the Bill & Melinda Gates Foundation, with support from the Carnegie Corporation of New York, the Ford Foundation, and the W. K. Kellogg Foundation. From 2002 to 2014, 280 ECs opened nationwide as part of the ECHSI (Webb and Gerwin 2014). The explicit goal of the ECHSI is to increase the opportunity for students who are traditionally underrepresented in postsecondary education to earn a postsecondary credential. The ECHSI's solution is to enroll traditionally underrepresented students in college courses while they are in high school and provide support from high school staff. According to large-scale evaluations conducted in the late 2000s, more than two thirds of EC students were nonwhite and almost 60 percent were economically disadvantaged, enrolling higher shares of nonwhite and

economically disadvantaged students than neighboring traditional public schools (Berger et al. 2009; Webb and Mayka 2011).¹

ECs are part of a wide array of programs that allow students to earn college credit in high school through dual-enrollment coursework. Many traditional high schools offer dual-enrollment opportunities, where students can enroll in college courses while in high school. In the 2010–11 school year, 82 percent of all public high schools and 98 percent of public two-year colleges in the United States offered dual enrollment opportunities (Marken, Gray, and Lewis 2013; Thomas et al. 2013). A more recent study of dual enrollment in Texas found that 93 percent of high schools and 99 percent of community colleges offered dual enrollment (Miller et al. 2018). As of the 2013–14 school year, there were 280 ECs serving more than 80,000 students (Webb and Gerwin 2014).

The EC approach is a specific model for delivering dual enrollment courses, where students take a larger number of dual enrollment courses that are provided through established course sequences and are offered a comprehensive support system intended to develop academic and behavioral skills necessary for college success (Berger et al. 2013). Although dual enrollment is often provided as an option for higher-achieving students, ECs intend to provide these opportunities to all students, and some ECs even focus on dropouts or students at risk of dropping out of high school (Smerdon et al. 2005).

Through the ECHSI, ECs partner with colleges and universities to offer enrolled students an opportunity to earn an associate's degree or up to two years of college credit toward a bachelor's degree during high school at no or low cost to the students. The underlying assumption is that engaging students who are underrepresented in a rigorous high school curriculum tied to the incentive of earning college credit (with reduced financial burden) will motivate them and increase their access to additional postsecondary education and credentials after high school (Berger et al. 2013).

In addition to offering dual enrollment, ECs provide a wide variety of academic and social supports—from personalized relationships with instructors to academic tutoring, advising, and help with study skills, time management, self-advocacy, other college “life skills,” and college preparation and application assistance (AIR and SRI 2008; Berger et al. 2009; Duffy et al. 2009; Cassidy, Keating, and Young 2010). ECs also provide supports in the formal transition to college, such as help with completing college applications and financial aid forms, which are important given that the complexity of the process is often a barrier to college attendance for academically qualified students from low-income families (Bettinger et al. 2009; Hoxby and Avery 2012). The combination of academic preparation and student supports in ECs is considered a best practice for helping students navigate the path to college (Tierney et al. 2009).

During the past decade, a growing body of research evidence has emerged, demonstrating the promise of ECs as an effective way to promote postsecondary access and

1. To meet the goal of enrolling traditionally underrepresented students, ECs engaged in a number of recruitment activities, including recruitment at neighborhood middle and high schools and community organizations, giving preference to traditionally underserved demographic groups (Smerdon et al. 2005). In addition to focusing recruitment on specific demographic groups, some ECs also set selection criteria related to student behavior and motivation, and academics, generally to select higher-performing students with lower behavioral problems (Smerdon et al. 2005).

success. Most of the existing studies of ECs, however, are descriptive and do not warrant causal conclusions about the impact of ECs. The only exceptions are two rigorous lottery-based natural experiments conducted by the SERVE Center (Edmunds et al. 2012, 2013, 2017) and AIR (Berger et al. 2013, 2014; Haxton et al. 2016). These studies found positive, rather substantial impacts of ECs on a variety of student outcomes, both during and after high school (e.g., high school graduation, college enrollment, and degree attainment).

In comparison, causal analyses on dual enrollment in comprehensive high schools suggest that participating students are between 2 and 4 percentage points more likely to obtain a two-year degree and less than 1 percentage point more likely to obtain a four-year credential, but results vary by student background and type of dual enrollment course (Speroni 2011; Allen and Dadgar 2012; Miller et al. 2018).² In other words, extant research suggests that by providing greater academic and social supports, a more structured dual enrollment course sequence, and more college credits, ECs are likely to have a larger impact on college outcomes than dual enrollment outside of ECs, yet prior studies do not examine whether those impacts are large enough to warrant the additional resources. Two other dual-enrollment programs, Advanced Placement and International Baccalaureate, are similar to dual enrollment, except students must pass a standardized test to obtain credit and course credits are more widely accepted at higher education institutions nationally. These two programs are also associated with positive college outcomes, but their target population is typically more academically advanced students (Giani, Alexander, and Reyes 2014).

Although several rigorous studies have examined the impact of ECs on student outcomes, few studies have examined the cost of ECs. Webb (2004) analyzed the budgets of six ECs to understand the planning and implementation cost of ECs and found substantial variation across different models of implementing ECs. Across six models, Webb estimated that yearly implementation costs ranged from almost \$6,400 per student for an EC contained within a traditional high school to almost \$16,000 per student for an EC partnering with a four-year university. The three models associated with two-year colleges ranged from \$9,200 to \$11,200 per student.³ The study was designed to provide insights into the monetary needs of opening a new EC and therefore did not attempt to compare the cost of ECs with traditional high schools. Information about the additional costs associated with ECs, over and above a “business-as-usual” traditional comprehensive high school, is more relevant for policy makers choosing between alternative strategies for boosting college completion. For a study of dual-enrollment education in Texas, Miller et al. (2018) estimated that ECs cost an additional \$110 per semester credit hour of college courses taken. Since EC students take an average of ten to twelve credits per year, that amounts to \$1,100 to \$1,320 more per student per year.

2. The three studies cited here are some of the few studies that have attempted to identify the effect of taking dual enrollment courses using research designs with strong causal inference. Allen and Dadgar (2012) used a difference-in-differences design; Speroni (2011) used a regression discontinuity design; and Miller and colleagues (2018) used an instrumental variables approach. Other studies, such as Cowan and Goldhaber (2015), used a modeling-based approach controlling for observable student characteristics and have weaker causal inference. Cowan and Goldhaber also found that dual enrollment students are more likely to attend college but are less likely to attend a four-year university full time.

3. Dollar figures were converted from 2004 dollars to 2017 dollars using the consumer price index to adjust for inflation.

To our knowledge, only a single study to date has compared the benefits of ECs to costs. The Washington State Institute for Public Policy (WSIPP) used costs from Webb (2004) and impact estimates from Berger et al. (2013) and Haxton et al. (2016) to estimate benefits. WSIPP (2018) estimated that the benefits of ECs exceed their cost by \$62,682 per participant, with a benefit–cost ratio of 16.5. However, the approach taken by WSIPP of combining costs and impacts from different studies could lead to flawed comparisons of costs and benefits. As we describe below, a better approach is to compare costs and benefits from the same sample. Furthermore, the impact estimates used in the WSIPP study examine students through a maximum of four years after their expected high school graduation. As was shown by Berger et al. (2013), Haxton et al. (2016), and Song and Zeiser (2019), EC students earn their degree faster than traditional high school students. Therefore, larger short-term impacts on college enrollment and degree attainment could diminish as non-EC students catch up. Our use of impact results over a longer time frame produces more accurate estimates of effects and monetary benefits.

Research Questions and Purpose

This study examines postsecondary outcomes of students six years after their expected high school graduation. Prior studies using lotteries followed students for a maximum of four years after expected high school completion (Berger et al. 2014; Haxton et al. 2016; Edmunds et al. 2017). By following all cohorts of students for six years after expected high school completion, this is the first study with an observation window sufficient in length (150 percent of normal time to completion) to examine impacts on bachelor's degree completion. In addition to examining the impacts of ECs on students' educational attainment, we conduct a social benefit–cost analysis, examining the comprehensive set of costs and benefits of ECs, inclusive of both public and private costs and benefits. We address the following research questions:

- (1) What is the impact of ECs on students' postsecondary attainment?
- (2) What is the monetary value of benefits of ECs per student?
- (3) How do the per-pupil costs of ECs compare with those of traditional high schools?
- (4) How do the benefits of ECs compare with their cost?

Policy makers ultimately want to know if an investment in ECs represents a sound, long-term advantage to both individual students and the public. By estimating the impact of ECs, translating that impact into monetary benefits, analyzing costs, and then comparing benefits to the cost of ECs, we provide valuable information to determine whether ECs represent a worthwhile educational investment.

Preview of Findings

Our impact analysis results indicate that ECs increase students' likelihood of attending and graduating from college with an associate's or bachelor's degree. The increased educational attainment attributed to EC enrollment results in lifetime benefits of almost \$58,000 per student. The cost of ECs is approximately \$950 more per student per year than traditional high school, or \$3,800 per student for four years of high school; but

we observed substantial variation in the cost of ECs across sites (from a low of \$2,279 less per student per year than to a high of \$4,616 more per student per year compared with the cost of traditional high schools). When comparing the benefits of ECs to the cost, the result is a net present value (NPV) of approximately \$54,000 per student and a benefit–cost ratio of 15.1. Even when using conservative estimates of the cost and benefits of ECs, we find that the benefits substantially outweigh the cost, with a benefit–cost ratio of 4.6.

2. METHODOLOGY

We first examined the impact of enrollment in ECs on postsecondary attainment, taking advantage of randomized admissions lotteries at a sample of ten ECs. Using these impact estimates and information from prior studies on both public and private returns to postsecondary education, we calculated the social benefits of ECs resulting from increased postsecondary attainment. Additionally, we collected primary data and administrative expenditure data on resource use from a subset of schools on which the impact estimates are based, and used these data to estimate the per-student cost of ECs above costs of traditional high schools in the same or neighboring district of the EC. We conducted a social benefit–cost analysis to examine the extent to which the benefits exceed the cost by calculating a benefit–cost ratio and NPV. Finally, we modeled the uncertainty of our cost and benefit estimates to determine the probability that the benefits exceed the costs. In this section, we overview the methods for the various components of this study.

Measuring the Impact of ECs

The impact analysis takes advantage of a multisite natural experiment with student-level random assignment. Specifically, we examined ten ECs that (1) enrolled students in grades 9–12, (2) had students who graduated high school by 2011, (3) used lotteries as part of their admission process for at least one incoming cohort for school years 2005–06 to 2007–08, (4) retained lottery records, and (5) implemented a whole-school EC program. The ECs included in the study were located in five states and were predominantly from urban areas. For the 2,458 students who applied for admission through the lottery process between 2005–06 and 2007–08, we collected data on postsecondary enrollment and graduation from the StudentTracker service from the National Student Clearinghouse.⁴ Information about who participated in the EC admission lotteries and who was offered admission to the EC was obtained from the ECs. Students' demographic information and achievement on grade 8 state assessments were obtained from participating districts and states. Data for students who applied to ECs in North Carolina came from a longitudinal experimental study on ECs led by the University of North Carolina at Greensboro SERVE Center.

To establish that the lottery process was indeed random, members of the research team examined lottery processes and records, replicating the randomization process when possible to confirm study samples. Successful randomization was also confirmed

4. Limiting the sample to those ECs that were oversubscribed and used lotteries may have implications for the external validity of this study. Because most ECs are not oversubscribed, the results of this study may not generalize to the population of ECs that are in operation.

Table 1. Treatment and Control Group Characteristics and Baseline Equivalence Tests

Student Characteristic	Treatment Group Average	Estimated Control Group Average	Estimated Treatment Group Difference	p
Female	51.4%	53.0%	−1.68 ppt	.483
Nonwhite	51.8%	52.1%	−0.35 ppt	.819
Low-income	49.4%	46.5%	2.88 ppt	.228
First-generation college-going	23.9%	22.9%	0.98 ppt	.704
Grade 8 ELA test score	0.212 SD	0.138 SD	0.074 SD	.077
Grade 8 mathematics test score	0.227 SD	0.234 SD	−0.007 SD	.889

Notes: N = 2,458 (1,044 treatment, 1,414 control). ELA = English language arts; ppt = percentage points; SD = standard deviations. The treatment group averages represent the unadjusted means for students accepted to Early Colleges (EC) via lottery. The estimated treatment group difference was estimated using an ordinary least squares regression of the student characteristic as the outcome variable with a treatment indicator variable and lottery (year by early college) fixed effects as the predictor variables. The estimated treatment group difference is the coefficient on the treatment indicator variable. The estimated control group average (for students not accepted to ECs via lottery) was calculated by subtracting the estimated treatment group difference from the treatment group average. Grade 8 ELA and mathematics test scores represent standard deviation differences from respective state means.

by examining baseline equivalence between students who won the EC admissions lottery and students who did not win the admissions lottery (see table 1). There were no statistically significant differences at conventional levels of statistical significance in the probability of being female, nonwhite, low-income, or having parents who had not attended college. Furthermore, there were no statistically significant differences in eighth grade mathematics or English Language Arts (ELA) test scores.⁵

The average characteristics of the treatment and control groups shown in table 1 also demonstrate that the student sample that participated in the lotteries at the ECs included in this study had relatively high levels of economic disadvantage (51.4 percent of the treatment group and 53.0 percent of the control group were eligible for free or reduced-price lunch) and were mostly nonwhite (51.8 percent of the treatment group and 52.1 percent of the control group).⁶ The students in the sample also tended to be higher-performing than average students in their respective states, performing approximately 0.2 standard deviations above the state average on their eighth-grade ELA and mathematics assessments, likely reflecting the fact that all students who applied to attend these ECs intended to earn college credit during high school.

Using data on students' postsecondary experiences, we classified students based on their terminal outcome six years after their expected high school graduation. Our classification of postsecondary attainment consists of four mutually exclusive categories describing the range of possible degree completion outcomes: (1) did not attend college, (2) attended some college without completing a degree, (3) completed an

5. We also conducted a test of joint significance using logistic regression to predict the likelihood of being in the treatment group based on the student characteristics included in table 1 (as well as lottery fixed effects). The test of joint significance of the student characteristic variables resulted in an F-statistic of 1.30 and a p value of .255.

6. In contrast, nationwide 55.8 percent of students were white and 42.4 percent were eligible for free or reduced-price lunch in the 2006–07 school year (Snyder and Dillow 2010). Although the ECs served relatively high proportions of low-income and minority students, the set of high schools in nearby districts attended by control students served higher proportions of minority and low-income students than the ECs (Berger et al. 2013).

associate's degree without completing a bachelor's degree, and (4) completed a bachelor's degree.⁷

Given that the outcome of interest has four mutually exclusive categories, we estimated the impact using multinomial logistic regression.⁸ We first estimated an intent-to-treat (ITT) model, where the explanatory variable of interest is an indicator of whether a student was admitted to an EC through the lottery. Because not all students who were accepted to an EC chose to enroll in the EC, these results are more conservative than what we would expect the actual impact of ECs to be.

The decision of whether to enroll in an EC after being accepted through the lottery (or somehow enrolling in an EC after not being accepted through the lottery) is not a random process, therefore we cannot directly estimate the impact of EC enrollment on student outcomes. To estimate the impact of EC enrollment on student outcomes (or the treatment-on-the-treated [TOT] effect), we specified a two-stage model. In the first stage, we estimated the impact of being accepted through the lottery on the likelihood of enrolling in the EC during the first year of high school using logistic regression. The second-stage model estimated the relationship between the predicted likelihood of EC enrollment and the categorical postsecondary attainment outcome using multinomial logistic regression.⁹ In other words, we used acceptance via the lottery as an instrument for EC enrollment. In this way, we isolated the random variation in enrolling in ECs due to acceptance via the lottery to generate internally valid estimates of the impact of EC enrollment.

To improve the precision of impact estimates, both the ITT and TOT models controlled for student gender, student race, whether the student's parents attended college, eighth-grade math and ELA test scores, and free or reduced-price lunch status. Lastly, the models accounted for unobserved differences between students who applied to different schools in different years by including lottery (EC by incoming cohort year) fixed effects.

For both the ITT and TOT models, we calculated average predicted probabilities for each outcome when categorizing all observations in the data as receiving the control and treatment conditions. For the ITT model the control condition was not being accepted via lottery and the treatment condition was being accepted to attend an EC via lottery. For the TOT model, the control condition was not enrolling in an EC (a predicted probability of 0 of enrolling in an EC) and the treatment condition was enrolling in an EC (a predicted probability of 1 of enrolling in an EC). We then calculated the average marginal effect, which represents the average difference between the predicted probabilities for each postsecondary attainment category under control and treatment conditions.

7. Additional information about the impact analysis, including the description of the data sources, how missing data were handled, and additional analyses examining the impact of ECs, can be found in Song and Zeiser (2019).

8. We also explored the use of ordinal logistic regression; however, tests of the parallel regression assumption of the ordinal logistic regression indicated that this assumption was not met (Long and Freese 2014). We, therefore, chose to go with the less constrained multinomial logistic regression.

9. Enrollment in this case is an indicator of whether a student enrolled in the EC during the ninth-grade year. Students could have attended the EC during ninth grade but then not attended in other high school years. Because of this, even the TOT estimates are likely more conservative than the impact of attending an EC for all high school years.

Converting Impact Estimates to Benefits

To convert the postsecondary attainment outcomes to estimated monetary benefits, we relied on prior studies that estimated the monetary returns of postsecondary education attainment. We identified six studies that estimated the private monetary returns of postsecondary education attainment and three studies that estimated the public monetary returns of postsecondary education.¹⁰ Private returns represent the estimated lifetime monetary returns to individual students due to increased earnings resulting from a given level of postsecondary attainment above a high school diploma. In addition to benefits to individual students, when people attend college and complete college degrees, benefits accrue to the public. Public monetary returns are those that accrue to society at large over the course of an individual's lifetime. Economists refer to public benefits that accrue from the consumption of a good or service (such as education) as positive externalities.

Using the identified studies, we generated two estimates of the monetary returns to postsecondary education: an average estimate and a conservative estimate. The average estimate combines all estimated returns to postsecondary education across studies into an average estimate for individuals who attend some college but do not earn a degree, who earn an associate's degree, and who earn a bachelor's degree. The conservative approach safeguards against overestimating the returns by using the lowest estimate of the returns to postsecondary education across studies. The use of the conservative estimate presents a lower bound estimate of the benefits of ECs.

We calculated the lifetime benefits attributable to ECs for each outcome by multiplying the differences in the percentages of students experiencing different postsecondary attainment outcomes between treatment and control students (the average marginal effect) estimated using the TOT model by the average and conservative returns for individuals with that level of education. The total lifetime benefits of ECs are the sum of the benefits across postsecondary attainment categories.

Calculating the Cost of ECs

We define the cost of ECs as the difference between the total cost of services provided to students in ECs and the total cost of services provided to students in local traditional high schools where control students most likely would have attended between 2005–06 and 2010–11, the years in which the students in our study attended high school.^{11,12} We used a hybrid approach to the cost analysis, relying on a combination of extant school-level expenditure data for the six ECs included in this component of the study and traditional high schools in the same or a neighboring district (in cases where the EC was an independent charter school), extant data on the cost of college at the partnering institutions of higher education (IHEs), and information from interviews with district and college officials to understand any additional costs that might not be accounted

10. Most studies reported the returns of postsecondary degrees as NPVs and, to make estimates comparable, we converted results to NPVs for those studies that did not report findings in this manner. Additionally, all estimates were converted to 2017 dollars using the consumer price index.
11. The control students were spread across 272 different high schools during the four years after participating in the EC admission lotteries, with many of those schools enrolling only one or two control students.
12. Although beyond the scope of this study, ECs also have start-up costs and we suspect that those costs may differ depending on the extent to which districts already have established relationships with IHEs. It should be noted that traditional high schools also have start-up costs that are not considered in this analysis.

for in extant spending data.¹³ Using these data we estimated a base cost for each EC consisting of school-level resources, and additional costs for instruction that occurs at the IHE, and costs at the district and IHE related to administering dual enrollment courses for each EC.

Because ECs represent a whole school model, rather than an add-on program, we defined the incremental cost of ECs as the difference in the total per-student cost of ECs and the average per-student cost across neighboring traditional high schools. We used several sources of data to identify various costs of ECs. First, we used school-level spending data, which consisted of the types and amounts of expenditures attributed to individual schools. We used these data to establish a base cost of each EC and all the traditional high schools in the same district.¹⁴ Because we were able to collect school-level spending data from six of the ten ECs included in the impact analysis, our cost estimates are based on those six ECs.¹⁵

Although school-level spending data are useful starting points, these data do not sufficiently capture instructional or administrative resources incurred at the IHEs. Schools or districts often are charged tuition by the IHE to cover the cost of student enrollment in courses. Tuition is a payment that represents a cost transfer from the IHE to the EC. The monetary value of the actual resources used for instruction and administration at the IHE may differ from the tuition amount; especially considering that not all IHEs charge a full tuition amount for dual enrollment programs, including EC programs. In Texas, for example, tuition rates are determined locally, with some IHEs charging full tuition, some IHEs charging reduced tuition amounts, and some IHEs waiving the cost of tuition entirely (Texas Association of Community Colleges 2017). Because of these issues with school-level spending data, we supplemented these data with several other sources of information to more accurately account for the additional administrative costs of ECs and the cost of instruction provided by IHEs.¹⁶

For several sites where the EC is part of a school district that partnered with an IHE to provide EC or other dual-enrollment opportunities, we interviewed district officials responsible for administering the district EC and dual-enrollment programs at two of the six ECs included in the cost analysis.¹⁷ From these interviews, we identified the

13. Ideally, cost would be determined through an in-depth “ingredients” approach, where all data on the specific personnel and nonpersonnel resources used to administer an intervention are collected by interviews and/or surveys (Levin et al. 2018). However, the fact that the intervention occurred seven to twelve years prior to the current study posed unique challenges for adopting this approach.
14. We assume school-level expenditure data provide a rough approximation of the cost to operate an EC and traditional high school, while recognizing that production inefficiencies may cause expenditures to exceed the actual cost.
15. Because each agency collects and reports spending data in different ways, we were limited in the amount of detail with which we were able to report spending for some sites. In addition, if we had more detailed data, we might have chosen to exclude certain types of expenditures, such as those for special education, because ECs often serve a substantially lower proportion of students who receive special education services compared with traditional schools. Because we could not separate out special education spending in each site, we chose to include such spending in the analysis. This might cause our school-level spending figures to slightly overstate spending in traditional high schools compared with ECs, thereby underestimating the relative cost of ECs.
16. For the purposes of the cost analysis, we excluded any spending representing tuition and fees—to avoid double counting—because we also included instructional and administration costs on the college side.
17. We found that most administrators in school districts or colleges did not place much distinction between EC and other dual-enrollment programs; therefore, we asked more generally about resources required to administer all dual-enrollment programs and calculated a cost per semester credit hour that accounted for both EC and traditional dual enrollment.

district-level resources used for administering EC and dual-enrollment programs and calculated the cost per semester credit hour of college courses taken through these programs. For the other two ECs included in the cost analysis that operate within a school district, we applied the average district-level administrative cost based on the interview data from the two EC sites where we conducted interviews. The two remaining ECs operate as independent charter schools. For these schools, district administrative costs were not included.¹⁸

To understand the cost of administering EC programs incurred by IHEs, we interviewed administrators at two colleges that partnered with the ECs. Based on the resources identified in these interviews, we calculated the administrative cost per semester credit hour of instruction, and we applied average college administrative costs at ECs partnering with IHEs where we did not conduct interviews.

To develop college instructional costs, we used data from the Integrated Postsecondary Education Data System from 2006 to 2011, which has information on average full-time teacher salaries, the share of instructors who are full time rather than part time, instructional spending, and the number of full-time equivalent students. These data allowed us to calculate college instructional costs for all partnering IHEs. Because of uncertainty expressed by college administrators in interviews regarding the actual level of college resources used by EC students, we calculated two versions of college instructional cost to represent lower and upper bounds on the estimates. The lower-bound estimate of instructional cost includes only the cost of instructor salaries and benefits. The upper-bound estimate captures all instructional cost per student incurred at a particular college (libraries, computer labs, tutoring services, etc.) and treats EC students the same as any other student attending a given college or university.

Using the described data sources, we estimated the total cost for ECs as well as traditional high schools in the same or surrounding district as the sum of the base costs (school-level expenditures), district administrative costs, college administrative costs, and college instructional costs. We then converted the total cost into the cost per pupil. To measure the differential yearly cost associated with ECs, we subtracted the traditional high school cost from the EC cost. Assuming that individual students attend ECs for four years, we calculated the total differential cost per student by multiplying the yearly difference by four. Using the upper-bound and lower-bound estimates of college instructional costs, we calculated upper and lower-bound estimates of the overall cost. Our preferred estimate, which we term the midpoint estimate, splits the difference between the upper and lower-bound estimates.

Comparing Costs and Benefits

We compared benefits to cost in two ways. First, we simply subtracted the cost from the benefits. The resulting difference is the NPV. Second, we calculated a ratio of benefits to cost by dividing the benefits by costs. The resulting ratio can be termed the benefit–cost ratio or the return on investment. We compared several sets of costs and benefits. Our preferred estimates of the NPV and benefit–cost ratio used the average estimate of

18. We only considered district administrative costs explicitly related to administering EC and dual enrollment programs. We assumed that general district administrative costs would be similar for both EC and non-EC students.

benefits and the midpoint estimate of costs. We also calculated conservative estimates that used both conservative costs (that err on the high side) and conservative benefits (that err on the low side) to identify a plausible lower-bound estimate of the NPV and benefit–cost ratio.

Lastly, we compared benefits to costs, separating benefits according to whether they are private or public. Using only private benefits represents the monetary value above the total cost that is accrued by individual students. However, because most of the associated cost of ECs is funded through public tax dollars, policy makers might place more value on the benefits accrued by the public rather than the benefits to the individual students.

Modeling Uncertainty

Because of the small sample of schools on which the cost estimates are based, we were unable to generate significance tests using the methods commonly employed with larger sample sizes. To model uncertainty, we performed Monte Carlo simulations that demonstrate how the results could vary if we replicated the study many times. Sources of potential error enter our analysis at three points: the estimation of the impacts of ECs, the estimation of benefits resulting from increased educational attainment, and the estimation of costs. At each stage, we modeled uncertainty by picking randomly generated estimates that were guided by the actual estimated parameters used in the benefit–cost analysis. Appendix table A.1 provides descriptions of how randomly generated numbers were used to simulate impact results, benefits, and cost.

After generating random estimates of the impact results, benefits of postsecondary attainment, and the costs of ECs above the cost of traditional high schools, we estimated the benefits attributable to ECs by multiplying the randomly selected impact results with the randomly selected benefits of postsecondary attainment. We then estimated the NPV by calculating the difference between the randomly selected benefits and cost. This exercise was replicated 10,000 times, resulting in 10,000 different NPV estimates. We examined the distribution of randomly estimated NPVs to understand the likelihood that the benefits exceeded the cost.

3. RESULTS

In this section, we present the results of each of the study components, starting with the impact estimates, followed by benefit and cost estimates, the comparison of benefits and costs, and the modeling of uncertainty.

The Impact of ECs

The ITT impact estimates are presented in table 2. The first column of values presented in the table are the multinomial regression logit coefficients for the treatment variable that identifies whether students were admitted to an EC through the lottery process. Multinomial regression estimates separate logit coefficients for each outcome category except for one, which represents the reference category, in our case, “no college.” The multinomial regression coefficients identify whether treatment results in an increased prevalence of a given outcome relative to the “no college” category. The logit coefficient for treatment status is statistically significant at $p < .01$ for the remaining three

Table 2. Intent to Treat Estimates of the Impact of Acceptance to an Early College on College Enrollment and Completion Outcomes, Six Years After Expected High School Graduation

	Multinomial Logit Coefficient	Average Predicted Probabilities		
		Not Accepted via Lottery	Accepted via Lottery	Average Marginal Effect
No college	(omitted)	28.3% (1.129)	21.1% (1.420)	− 7.2 ppt***
Some college/no degree	0.329** (0.127)	44.9% (1.366)	43.7% (1.636)	− 1.2 ppt (2.255)
Associate's degree/no bachelor's degree	1.030*** (0.195)	6.5% (0.714)	11.2% (0.909)	4.7 ppt*** (1.205)
Bachelor's degree	0.659*** (0.158)	20.3% (1.100)	24.1% (1.128)	3.7 ppt* (1.659)

Notes: $N = 2,458$ (1,044 treatment, 1,414 control). ppt = percentage points. Standard errors are in parentheses. The multinomial regression model used to estimate these results controls for student gender, student race, whether the student's parents attended college, eighth-grade math and English Language Arts test scores, and free or reduced-price lunch status. The regression model also includes lottery (year by Early College) fixed effects.

*** $p < .001$; ** $p < .01$; * $p < .05$.

outcomes, indicating that students who were accepted to an EC via lottery were more likely than students who were not accepted to the EC to have some college without earning a degree, to have earned an associate's degree but not earned a bachelor's degree, and to have earned a bachelor's degree, relative to not attending college.

To ease interpretation, we estimated the average predicted probabilities of each outcome under control (non-EC) and treatment (EC) conditions. Had all students in the sample not been accepted to an EC, the model predicts that 28.3 percent would not have gone to college, 44.9 percent would have attended college but not earned a degree, 6.5 percent would have earned an associate's degree but not a bachelor's degree, and 20.3 percent would have earned a bachelor's degree. Results show that if all students had been accepted to an EC, the commensurate figures are 21.1 percent, 43.7 percent, 11.2 percent, and 24.1 percent, respectively.

The difference between the average predicted probabilities represents the average marginal effect—in this case the average ITT effect. Had all students been accepted to an EC compared with not having been accepted through the lottery, the model predicts a 7.2-percentage point reduction in the probability of not attending college, a 1.2-percentage point reduction in attending some college but not earning a degree, a 4.7-percentage point increase in the likelihood of earning an associate's degree but not earning a bachelor's degree, and a 3.7-percentage point increase in the likelihood of earning a bachelor's degree. All marginal effects except for the effect on some college/no degree are statistically significant at $p < .05$. Overall, the results indicate that acceptance to an EC had a statistically significant effect on increasing the probability of degree attainment and reducing the probability of not attending college.

The ITT estimates provide information about the impact of winning an EC enrollment lottery, which is useful for thinking about how a lottery for EC admission will impact a group of students. However, the TOT estimates are perhaps more relevant for policy makers because they show the specific impact of enrolling in an EC compared with a traditional comprehensive high school. These estimates are presented in table 3. The first stage estimates indicate that students who were accepted to an EC via lottery

Table 3. Two-Stage Treatment-on-the-Treated Estimates of the Impact of Early College (EC) Enrollment on College Enrollment and Completion Outcomes, Six Years After Expected High School Graduation

1st-Stage Estimates (effect of being accepted via lottery on EC enrollment)				
	Logit Coefficient	Average Predicted Probabilities		Average Marginal Effect
		Not Accepted via Lottery	Accepted via Lottery	
EC enrollment	6.290*** (0.543)	3.0% (0.702)	70.5% (1.953)	67.5 ppt*** (2.010)
2nd-Stage Estimates (effect of EC enrollment on postsecondary attainment)				
	Multinomial Logit Coefficient	Average Predicted Probabilities		Average Marginal Effect
		Did Not Attend EC	Attended EC	
No college	(omitted)	28.8% (1.309)	18.2% (1.995)	−10.7 ppt*** (2.740)
Some college/no degree	0.515*** (0.196)	45.0% (1.458)	43.6% (2.209)	−1.3 ppt (3.147)
Associate's degree/no bachelor's degree	1.481*** (0.292)	6.2% (0.743)	13.2% (1.441)	7.1 ppt*** (1.881)
Bachelor's degree	0.949*** (0.203)	20.0% (1.125)	25.0% (1.497)	5.0 ppt* (2.039)

Notes: *N* = 2,458 (1,044 treatment, 1,414 control). ppt = percentage points. Standard errors are in parentheses. Standard errors for the second stage were estimated through bootstrapping, as described in Cameron and Trivedi (2010). The first stage was estimated using logistic regression and the second stage was estimated using multinomial logistic regression. Both stages include controls for student gender, student race, whether the student's parents attended college, eighth-grade math and English Language Arts test scores, and free or reduced-price lunch status. The regression models also include lottery (year by EC) fixed effects.

****p* .001; ***p* .01; **p* .05.

were significantly more likely to enroll in an EC. Students accepted to an EC via lottery are predicted to have enrolled in an EC in ninth grade 70.5 percent of the time. In contrast, students not accepted to an EC via lottery are predicted to have enrolled in an EC only 3 percent of the time.

The second stage estimates describe the impact of EC enrollment on postsecondary attainment. The TOT estimates are larger in magnitude than the previously presented ITT estimates. The second stage multinomial logit coefficients are all statistically significant, indicating that enrolling in an EC increased the probability of enrolling in college, earning an associate's degree, and earning a bachelor's degree, relative to the probability of not enrolling in college at all.

The model predicts that enrolling in an EC resulted in a 10.7-percentage point reduction in the probability of not going to college, a 1.3-percentage point reduction in the probability of attending college without earning a degree, a 7.1-percentage point increase in the likelihood of earning an associate's degree, and a 5.0-percentage point increase in the likelihood of earning a bachelor's degree. The average marginal effects on no college, earning an associate's degree, and earning a bachelor's degree are all statistically significant at *p* < .05.¹⁹

19. The focus of the impact analysis for this paper is on the overall average effect on postsecondary attainment for the purpose of calculating benefits. We also examined whether outcomes differed by student characteristic and whether EC students were less likely to attend selective four-year colleges. We found no differential effects

The Benefits of ECs

We identified six studies of private returns resulting from a given level of postsecondary attainment above a high school diploma (shown in Appendix table A.2). The dollar amounts estimated in these studies represent the typical (average or median, depending on the study) increase in earnings over the course of a lifetime for an individual with a given level of postsecondary attainment above a high school degree. All six studies measured the monetary returns of obtaining a bachelor's degree. Agan (2013) and Hershbein and Kearney (2014) also included the monetary returns of earning an associate's degree and attending college but not completing a degree.

Focusing on bachelor's degrees, we see quite a bit of variation in the estimates of private market returns from postsecondary attainment—from a low of \$209,654 in Agan (2013) to a high of \$666,978 in McMahon (2009). One primary reason for these differences is the amount of time over which the studies measured the accrued returns. Agan, for example, measured returns only for the first thirty years after college entry. Assuming college entry at age 18 years, this would account for returns accrued to individuals through age 48 years. Hershbein and Kearney (2014) measured returns across forty years. McMahon reported an average yearly return of \$31,000 per year after completing college. When converting this average yearly return to an NPV across forty years, it amounts to \$666,978.²⁰

In addition to private market monetary returns, McMahon (2009) also identified private nonmarket returns as a key category of the benefits of postsecondary attainment. These returns are those that accrue to the individual who participated in higher education over the course of a lifetime but are not related to the wages that individuals earn. Benefits within this category include better individual health, increased longevity, better health of an individual's children and spouse, improved education for an individual's children, and better choices related to purchasing and saving of money. According to McMahon's calculations, private nonmarket returns were approximately

by gender, race, or low-income status. We did find stronger impacts of ECs on enrollment in a two-year college and completion of an associate's degree for students with high prior performance. We also found no impact on the likelihood of enrolling in a selective four-year college. See Song and Zeiser (2019) for additional impact analysis results.

20. Another factor accounting for differences in estimated returns is whether the studies accounted for the cost of attending college. Agan (2013) and Avery and Turner (2012) subtracted the cost of attending college from their calculations, whereas the remaining studies do not. For the purpose of calculating costs and benefits of ECs, the additional postsecondary attainment earned by EC students might result in an induced cost from having to pay for more college that one would not have attended if not for enrolling in an EC. These induced costs can be accounted for either through additional costs on the cost side of calculations or as a reduction in benefits on the benefit side of the calculation. As described in the study methodology on the calculation of costs, we account for the cost of any college credits earned during high school as part of the cost analysis. For there to be induced costs related to increased educational attainment, EC students would have to take more college credits post-high school compared to traditional students. Given that EC students earn substantial numbers of credits during high school, it is not clear that there would be induced costs related to more credits taken post-high school by a typical EC student. The subtraction of the cost of college by Agan and Avery and Turner from the returns to postsecondary education is, therefore, conservative for the purposes of this study and would result in an assumption that all postsecondary attainment gains by EC students were the result of college courses taken after high school. Even our average costs, where the cost of college is deducted from two of the studies, could be conservative if the increased educational attainment of EC students is attributed to credits earned during high school and not from increased credits taken after high school completion. Because of the likely conservative nature of our existing benefits estimates, we did not further attempt to correct for the possibility of induced costs of increased educational attainment of ECs.

Table 4. Applied Average and Conservative Estimates of Private and Public Returns of Postsecondary Education by Education Level

	Average Estimates		Conservative Estimates	
	Private Benefits	Public Benefits	Private Benefits (Agan 2013)	Public Benefits (Carroll and Erkut 2009)
Some college/no degree	\$112,518	\$73,535	\$73,143	\$46,728
Associate's degree/no bachelor's degree	\$223,948	\$147,071	\$144,884	\$93,456
Bachelor's degree	\$392,158	\$294,143	\$209,654	\$186,911

Notes: Dollars are inflation-adjusted using the consumer price index to represent 2017 dollars. Average estimates were computed as the exponentiated average of the logged dollar values across the six public benefit studies and three private benefit studies. For studies that did not specify benefits of an associate's degree or a bachelor's degree, benefits were assumed to decrease at a constant rate. Specifically, private returns to an associate degree were assumed to be 57.5 percent of the private returns of a bachelor's degree. This was the average ratio of private returns of associate degree to bachelor's degree benefits for studies including both associate's degree and bachelor's degree benefits. The ratio of some college–no degree to associate's degree private benefits was assumed to be 50.2 percent, the average ratio for studies including both categories of private benefits. The ratio of public returns of an associate's degree to bachelor's degree was assumed to be 50 percent, as was the ratio of public returns of some college–no degree to an associate's degree. Note that for Carroll and Erkut (2009), the 50 percent ratio was applied to the returns of a bachelor's degree to estimate returns for some college/no and associate's degree/no bachelor's degree. These estimates straddle the reported estimate of public returns for “some college” found in the paper, which lumped together associate's degrees with some college/no degree, suggesting the 50 percent ratio is a reasonable assumption.

22 percent larger than private market returns, or \$814,713 during the course of an individual's lifetime.

We also identified three studies that estimate public returns from individuals completing postsecondary education by education level (see the bottom panel of Appendix table A.2). Trostel (2010) and Carroll and Erkut (2009) identified public returns as increased taxes or decreased government spending (e.g., decreased dependence on federal assistance programs). McMahon (2009) used a more expansive definition of public benefits—social benefits in his terminology—and included such benefits as democratization, human rights, longer life expectancy, less pollution, and reduced inequality. Unsurprisingly, the value of lifetime public returns of a bachelor's degree estimated using McMahon's broader definition of public benefits (\$593,204) is more than double the estimates from Carroll and Erkut and Trostel (\$186,911 and \$229,525, respectively).

Given the wide range of returns estimated by various studies, we used two different estimates of the returns to postsecondary education to calculate the benefits of ECs: an average and conservative estimate. The applied average and conservative returns can be found in table 4. For the conservative estimates, we used the private market returns from Agan (2013) and the public returns from Carroll and Erkut (2009). For the public returns of attending college but not earning a degree, neither Carroll and Erkut nor Trostel (2010) provided estimates. Therefore, we assumed that the public returns of some college but no degree are half the returns of obtaining an associate's degree. Note the average estimated returns are slightly less than double the conservative estimate of returns.²¹

Table 5 presents the benefits attributable to enrolling in an EC. These are the returns to postsecondary attainment multiplied by the estimated TOT impacts of ECs. The

21. We chose not to apply the private nonmarket returns because the only source of these estimates was from McMahon (2009). Liberal estimates of returns inclusive of private nonmarket returns by McMahon are approximately five times the conservative estimate of total private and public returns. The omission of private nonmarket benefits suggests that even our average estimates of benefits are likely conservative compared to the true level of benefits.

Table 5. Average and Conservative Estimates of Private and Public Benefits Attributable to Early College Enrollment

	Average	Conservative
Private benefits	\$33,709	\$19,601
Public benefits	\$23,973	\$15,233
Total private and public benefits	\$57,682	\$34,834

Notes: Dollars are inflation adjusted using the consumer price index to represent 2017 dollars. Estimated benefits are the product of the estimated difference in postsecondary outcomes between Early College and traditional students and the estimated returns to postsecondary education.

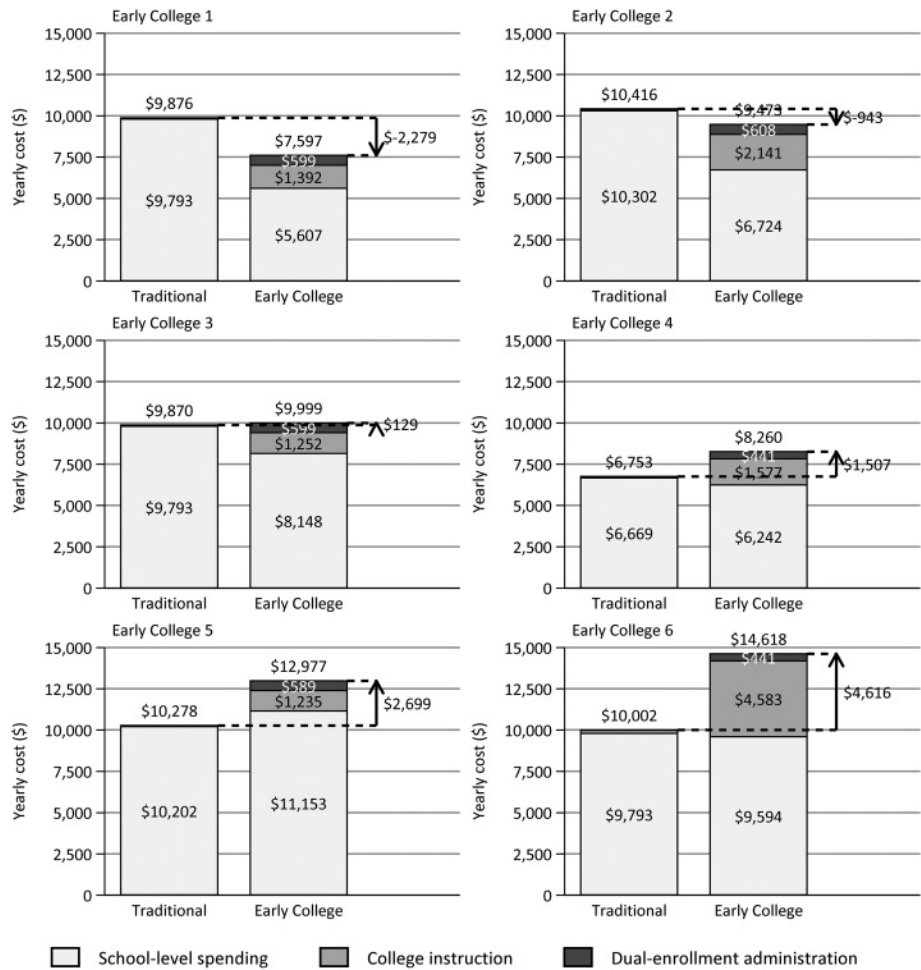
average estimate of lifetime benefits of enrolling in an EC is \$57,682 per student, with \$33,709 per student in private benefits and \$23,973 per student in public benefits. The conservative estimates of benefits amount to \$34,834 per student in total benefits, with \$19,601 per student in private benefits and \$15,233 per student in public benefits.

The Cost of ECs

Figure 1 shows comparisons of EC and traditional high school costs for each of the six ECs included in the cost analysis. Cost is broken down into three components: (1) school-level spending consisting of expenditures reported for the EC or traditional high schools; (2) college instructional costs accounting for the delivery of college courses to high school students; and (3) dual-enrollment administrative costs consisting of both district and college administrative cost incurred specifically for delivering dual-enrollment instruction for either traditional high school students or EC students. All school districts in our sample offered dual-enrollment in their non-EC high schools. School district administrators noted in interviews that ECs did not require any significant administrative costs over and above the costs of administering dual-enrollment courses; however, more staff time was allocated to administering dual-enrollment in ECs because students in ECs earned a greater number of dual-enrollment credits compared to students in non-EC high schools. The college instructional costs presented in figure 1 represent our preferred estimates (the midpoint between the lower and upper bounds). It should also be noted that administrative cost does not account for general district administration, which is assumed to be the same for both EC and traditional high school students, and does not represent school administrative cost, which is captured by school-level spending.²²

For traditional high schools, almost all costs consist of school-level spending. Only a small fraction of the cost is attributed to dual-enrollment administration or college instruction and administration. This is a result of how we define administration. For the purposes of making cost calculations, administration includes only the cost associated with administering dual-enrollment or EC programs on either the district or

22. In addition, we did not capture other centralized non-administrative costs that were not included in school-level expenditure data. This would include student transportation, for example. It should be noted that the school-level spending data in at least one of the ECs did account for the additional student transportation spending required to bus students to the college campus. The two other sites with detailed spending data do not appear to contain spending on transportation.



Notes: Dollars are inflation adjusted using the consumer price index to represent 2017 dollars. College instructional and administration costs are included on the traditional side but are not labeled because of the small amount. Administration costs represent only the incremental district and college administrative costs associated with dual-enrollment or ECs.

Figure 1. Estimated Cost of Traditional Comparison High Schools and Early Colleges (ECs)

college side. Many traditional high schools offer dual enrollment and therefore also incur costs related to college instruction and the administration of dual-enrollment programs. However, because our assumption is that traditional students take 0.5 credit per year on average and EC students take 12 credits per year on average, the per-student cost of dual-enrollment administration and college instruction is much larger for EC students than for traditional high school students.²³

23. This assumption of the number of credits taken for traditional high school students and EC students is calculated based on administrative data of dual-enrollment credits taken by Texas high school students. Additionally, the goal of completing a two-year credential during high school would suggest that students would need to take fifteen credits per year to complete the sixty credits required for a two-year degree within four years of high school.

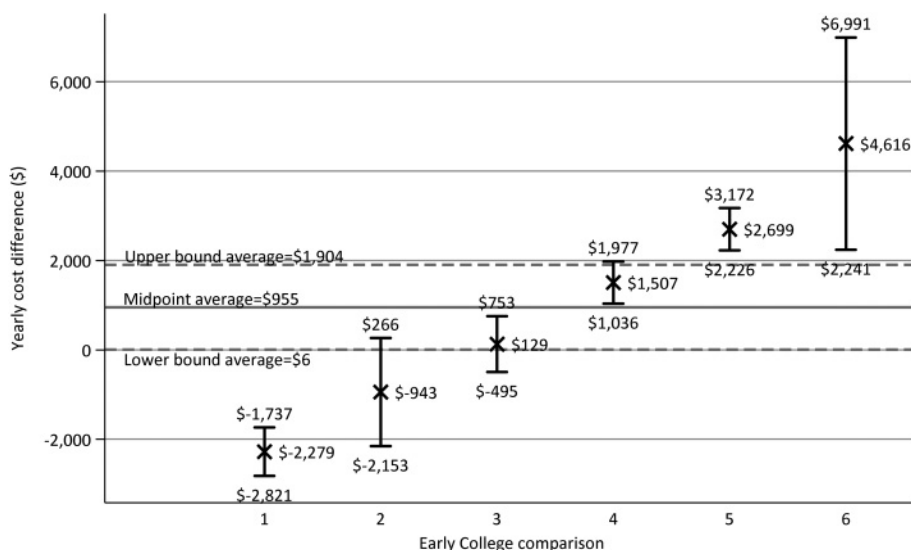
The results presented in figure 1 illustrate large variation in EC costs within our sample, with a minimum per-student cost of \$7,597 (EC 1) and a maximum per-student cost of \$14,618 (EC 6).²⁴ In contrast, with the exception of one average traditional high school cost of \$6,753 per student, the average per-student cost of traditional schools in the sample ranged from \$9,870 to \$10,416.

The key element impacting variation in EC costs across sites is the amount of school-level spending in ECs, which ranged from approximately \$5,607 per student at one site to \$11,153 at another site. In five of the six EC-traditional high school comparisons, school-level spending at ECs was lower than at the traditional high schools. This is largely to be expected because EC students take a large amount of their coursework on college campuses from college faculty. This means that ECs can employ fewer instructional staff and can devote fewer resources toward facility costs. However, ECs may have nonpersonnel costs that exceed those of traditional high schools. In particular, textbooks for college courses are expensive and are updated more frequently than those for high school courses. In addition, ECs may have to bus students to and from the college campus if the EC facility is not located on the college campus.

The differences in cost estimates between ECs and traditional high schools are presented in figure 2. For each EC, we present the lower bound, midpoint, and upper bound of the cost difference calculated using the different iterations of college instructional cost. In addition, figure 2 shows the overall average of the lower-bound, midpoint, and upper-bound differences. The lower-bound average difference indicates that ECs cost only \$6 more per student per year than traditional high schools, whereas the upper bound indicates ECs cost \$1,904 more per student in yearly cost, with a midpoint difference of \$955 per student. These estimates align with Miller et al. (2018), who estimated an additional cost of ECs of \$110 per college credit using a more traditional ingredients approach. The cost of \$110 per credit equates to \$1,100 to \$1,320 per student per year since students in their data took ten to twelve credits per year on average, which is slightly higher than our average estimate but less than our conservative cost estimate. Our cost estimates also align with those estimated by WSIPP (2018), which estimated a total program cost of \$4,034 or just over \$1,000 per year of high school.

To better understand the differences in the school-level spending cost component between ECs and traditional high schools, we conducted a detailed comparison of the school-level spending data for three sites, where the EC and traditional high school spending was reported in the same format. Figure 3 shows the difference in per-pupil spending between ECs and traditional high schools for the three sites in three categories of spending—instruction, facilities maintenance and operations, and all other spending. The top panel of the figure consists of only personnel spending, the middle panel consists of only nonpersonnel spending, and the bottom panel consists of overall spending (personnel and nonpersonnel combined).

24. The high cost of EC 6 is largely attributed to higher college instructional costs compared with the other ECs. The college instructional cost for EC 6 is more than double the college instructional cost at any of the other ECs, which is explained by the fact that EC 6 partnered with a state flagship four-year public university. Three of the other six ECs partnered primarily with community colleges. The remaining ECs partnered with a four-year university that is not a state flagship university. The college instructional costs at the flagship university were substantially higher than those estimated at the other partnering colleges and universities in the sample. A higher per-student cost for an EC partnering with a four-year university is consistent with the findings on EC costs reported by Webb (2004).



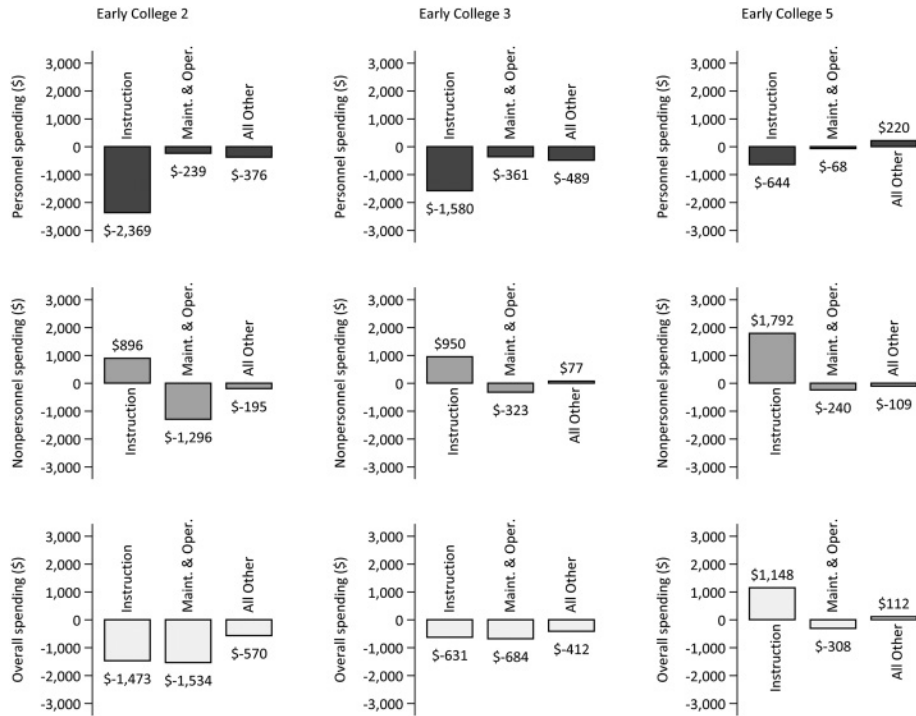
Notes: Dollars are inflation adjusted using the consumer price index to represent 2017 dollars. For each EC, a lower-bound, midpoint, and upper-bound estimate of cost is shown. The lower-bound cost estimate assumes that college instructional costs for EC students consist only of instructor salaries and benefits. The upper-bound cost estimate assumes that EC students take full advantage of college instructional resources as any traditional student would. The midpoint cost estimate splits the difference between the lower- and upper-bound estimates. Average upper- and lower-bound estimates are shown using gray dashed lines. The midpoint average estimate is shown using a solid thick gray line.

Figure 2. Lower-Bound, Midpoint, and Upper-Bound Estimates of Yearly Cost Differences Between Early College (EC) and Traditional High Schools

Looking at overall spending, in all three sites spending on facility maintenance and operations was the category where traditional high schools most outspent ECs (represented by negative values), indicating that ECs save on school operational facility costs compared with traditional high schools.²⁵ In ECs 2 and 3, instructional spending was the category with the second largest difference between ECs and traditional high schools, where traditional high schools outspent ECs. In EC 5, by contrast, instruction was the category where the EC outspent traditional high schools by the largest amount.

In all three schools, however, traditional high schools outspent ECs on instructional personnel, whereas ECs outspent traditional high schools on nonpersonnel instructional costs, a category that includes textbooks and other supplies. In ECs 2 and 3, the negative differences between ECs and traditional high schools in instructional personnel substantially outweighed the positive differences in nonpersonnel instructional costs, leading to a lower overall school-level cost among ECs. In EC 5, however, the positive difference in nonpersonnel instructional costs was greater in magnitude than the negative difference in personnel spending, leading to greater overall school-level costs at the EC relative to traditional high schools. The patterns of school-level spending observed in ECs compared with traditional high schools suggest that ECs are realizing cost savings on school-level instructional personnel and facilities but are spending

25. It should be noted, however, that we did not attempt to measure the possible increase in facilities costs to colleges resulting from EC partnerships.



Notes: Dollars are inflation adjusted using the consumer price index to represent 2017 dollars. Negative differences denote that ECs spend less in the given expenditure category. The upper panel shows only the differences in personnel spending used for instruction, maintenance and operations, and all other expenditure categories. The middle panel shows nonpersonnel spending by the three expenditure categories. The bottom panel shows personnel and nonpersonnel combined by the three expenditure categories.

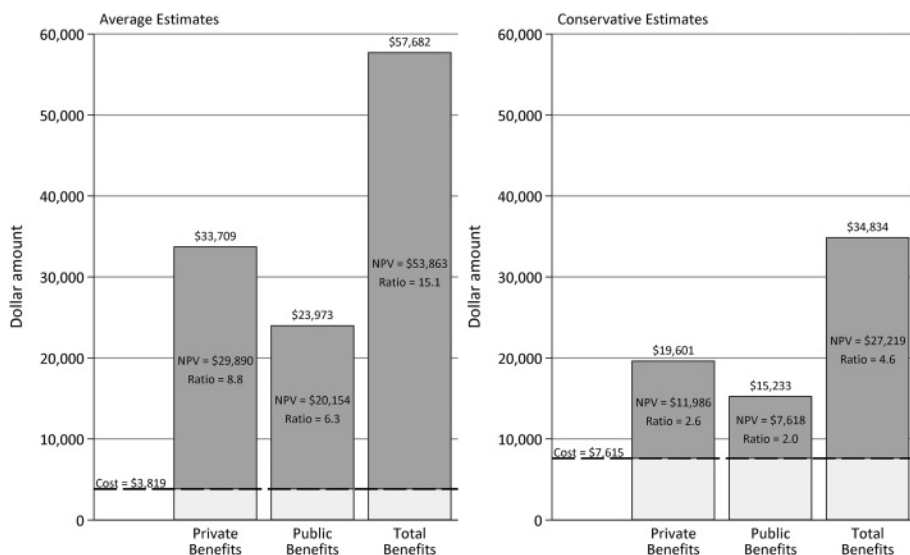
Figure 3. Differences in School-Level Spending Between Early Colleges (ECs) and Traditional High Schools by Spending Function

more on nonpersonnel instructional costs.²⁶ However, as we observed in figure 1, for most ECs cost savings at the school level are smaller than the additional cost of college instruction and administration, leading to higher overall costs at ECs compared with traditional high schools.

The Benefits to Costs of ECs

Here we present comparisons of both average and conservative costs and benefits associated with ECs. As previously stated, the average estimates are our preferred estimates of the costs and benefits because they rely on midpoint estimates of costs and average estimates of the benefits, whereas the conservative estimates will result in lower-bound estimates of the NPV and benefit–cost ratio. For average cost, we used the average of the midpoint cost differences across the six EC-traditional high school comparisons: \$955 per student per year. Because students typically attend ECs and traditional high schools for four years, we multiplied the yearly difference of \$955 by four to get a total cost difference of \$3,819, indicating that ECs cost \$3,819 more per student than

26. These patterns also conform to prior research on the costs of EC and dual enrollment education. For example, Miller et al. (2018) found that some districts realize cost savings from their dual enrollment programs through the savings on school-level personnel costs that result from students taking courses taught by college faculty.



Notes: Dollars are inflation adjusted using the consumer price index to represent 2017 dollars. The net present value (NPV) is the difference between benefits and cost. The ratio represents the benefits divided by cost. The darker portion of the bars is the portion of benefits that are above and beyond the cost. Therefore, the darker portion represents the NPV.

Figure 4. Comparison of Average and Conservative Estimates of Cost and Benefits of Early College

traditional high schools.²⁷ The average estimates of benefits indicate that enrollment in an EC results in \$33,709 in private benefits, \$23,973 in public benefits, and \$57,682 in total benefits.

As shown in figure 4, if we account for all benefits (public and private), the NPV of the average estimates is \$53,863, and the benefit–cost ratio is 15.1. In other words, using the average estimates of benefits and costs, we found that benefits are more than fifteen times the cost. If we consider only the private benefits but still use the overall cost, we calculate an NPV of \$29,890 per student and a benefit–cost ratio of 8.8. Accounting only for public benefits, the NPV using average estimates is \$20,154 per student, and the benefit–cost ratio is 6.3.

Our conservative estimates use the upper-bound average yearly difference of costs (\$1,904). Multiplied by four, to account for four years of high school enrollment, the conservative cost estimate is \$7,615 per EC student. Conservatively estimated private benefits of ECs are \$19,601 per student, public benefits are \$15,233 per student, and total benefits are \$34,834 per student.

The NPV using conservative estimates of costs and total benefits is \$27,219, for a benefit–cost ratio of 4.6. Using only the public portion of benefits, we calculate a conservative NPV of \$7,618 and a benefit–cost ratio of 2.0. Therefore, even when using what we consider to be conservative estimates of benefits and cost, the benefits in total are 4.6 times the cost, and public benefits alone are still two times the cost.

27. Some ECs operate as five-year programs, however, all the ECs included in the cost analysis portion operated as four-year programs.

Break-Even Analysis

How high would the costs associated with ECs have to be to outweigh the benefits? If we use our conservative estimate of total benefits as the outcome of interest, cost would have to be \$34,834 per student. This equates to a yearly cost of \$8,709 per student. Using conservative (upper-bound) estimates of cost, none of the six ECs had yearly costs that exceeded the cost of traditional high schools to that extent, with the costliest EC having a conservative yearly cost difference of \$6,991 per student. Given that even when using our most conservative estimates none of the six early colleges had costs that exceed the estimate of benefits, we suspect that very few individual ECs nationally have costs in excess of the total benefits, and it appears unlikely (despite our small sample size) that the cost of ECs exceed the total benefits on average.²⁸

If policy makers, however, are solely concerned with the public benefit from ECs, a cost of \$15,233 per student would be the point at which the cost is equivalent to our conservative estimate of public benefits. This amounts to a yearly cost of \$3,808 per student above the cost of traditional high schools. Our conservative estimates of cost exceed this amount for one of the six ECs for which we collected cost data. This suggests cost may exceed public benefits at a small share of ECs.

Simulations Modeling Uncertainty

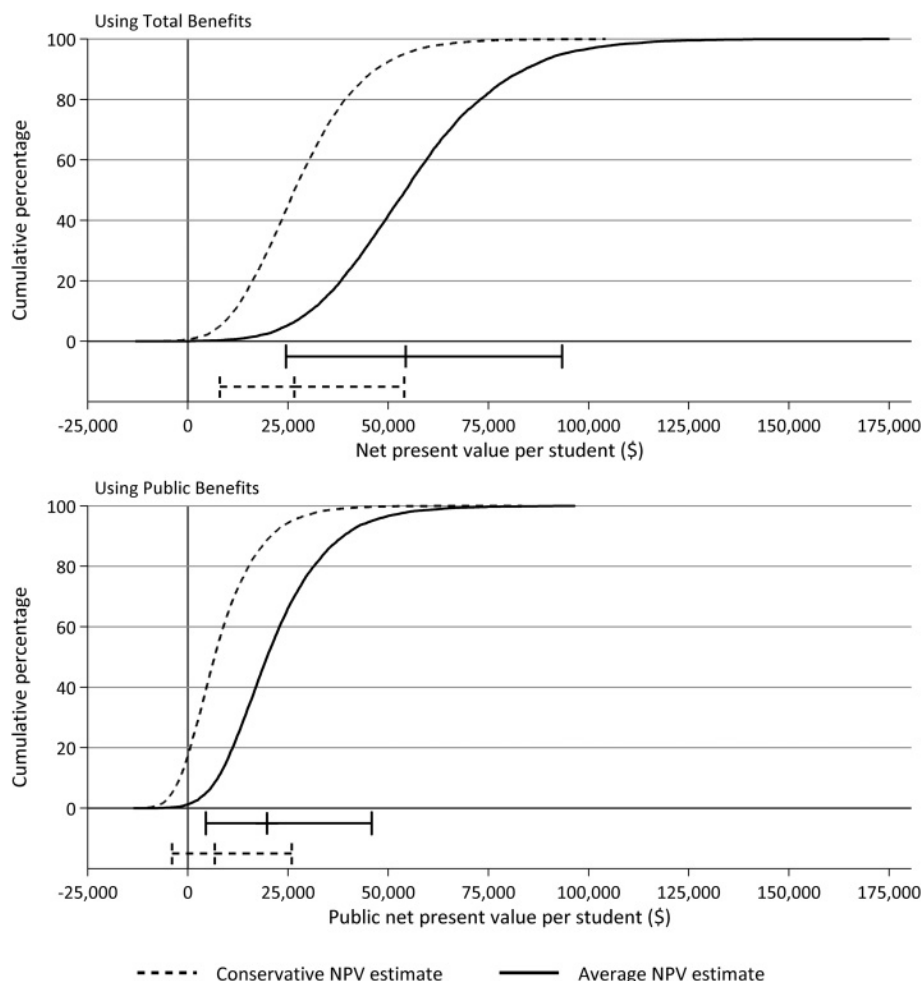
Figure 5 displays the results of the simulated NPV estimates. The top panel of the figure uses total benefits (private and public combined) and the bottom panel uses only public benefits. The curved lines in the figures represent cumulative percentages of the simulated estimates. Any point on the curved lines shows the percentage of simulated values that fall below a given dollar amount. The range bars in the lower portion of both panels of the figure display the 5th to 95th percentile ranges as well as the median value.

When using total benefits, less than 0.1 percent of average simulated NPVs fell below zero.²⁹ Furthermore, the 5th percentile of the simulated average NPV was over \$24,000 per student. The median simulated average NPV was approximately \$54,000 per student. Even when using conservative simulated estimates of costs and benefits, over 95 percent of the resulting simulated NPV estimates were positive; less than 1 percent of the simulated conservative NPV estimates were below zero. The 5th percentile of conservative NPV estimates was almost \$8,000 per student. The median of the conservative NPV estimate using total benefits was more than \$26,000 per student.

When considering only public benefits, the simulated average NPV was still overwhelmingly positive. The 5th percentile of the NPV was over \$4,000 and less than 2 percent of simulated NPVs using only public benefits were below zero. The median simulated public NPV was almost \$20,000 per student. Of the four scenarios, only the NPV of conservative estimates restricted to public benefits was negative more than 5 percent of the time. The simulated conservative estimates of the public NPV were less

28. One limitation of the comparison of costs and benefits in this study is that the estimate of benefits is based on the impact estimates including ten ECs, whereas the cost estimates are based on only six ECs. For the remaining four ECs to tilt tip the balance of our conservative estimates so that costs exceed benefits, the four remaining ECs would have to cost an average of almost \$19,000 more per student per year than traditional high schools. Costs of this level are exceedingly unlikely.

29. Five percent is the threshold for what we might consider statistically significant.



Notes: Dollars are inflation adjusted using the consumer price index to represent 2017 dollars. The curved cumulative percentage lines show the percentage of simulated results that fall at or below a given NPV. Horizontal range bars at the bottom of the figure depict the 5th to 95th percentile range as well as the median estimate. The top panel shows simulated NPVs using total benefits (public and private) and the bottom panel shows NPVs considering only public benefits.

Figure 5. Monte Carlo Simulation Results for the Net Present Value (NPV)

than zero approximately 17 percent of the time. This exercise in modeling uncertainty indicates a strong likelihood that the benefits of ECs exceed the costs.

4. DISCUSSION

Summary of Findings

The EC model is intended to better bridge the gap between secondary and postsecondary education enrollment by providing students the opportunity to participate in college education during their high school years. Previous EC impact studies (Berger et al. 2013; Haxton et al. 2016; Edmunds et al. 2017), as well as the analyses presented in this paper, found strong positive impacts of ECs on students' educational attainment. In this paper, we combined our newly estimated impact results with a social benefit–cost

analysis to examine whether the benefits associated with ECs outweigh any additional costs.

The estimated impact results indicated that EC students were more likely to attend college and more likely to complete their postsecondary education with an associate's degree or a bachelor's degree. Using existing studies that quantified the monetary private and public returns to postsecondary education, we estimated the benefits attributable to EC enrollment through increased postsecondary education attainment. Using average estimates of benefits, we calculated that EC enrollment resulted in benefits of almost \$58,000 per student, with almost \$34,000 of benefits going to the students themselves and approximately \$24,000 of benefits going to the public at large. Using conservative estimates of the returns to postsecondary education, we calculated that EC enrollment resulted in approximately \$35,000 of benefits per student, with almost \$20,000 in private benefits to the individual student and over \$15,000 in benefits to the public.

Using a variety of data sources, including school-level spending data on high schools, postsecondary data on instructional spending, and interviews with individuals at ECs, districts, and colleges, we estimated the cost of providing an EC high school education compared with traditional high schools for six ECs. Averaged across the six ECs, our preferred estimate indicated that ECs cost approximately \$950 per student per year more than traditional high schools. Conservative estimates indicated that ECs could cost as much as \$1,904 more per student per year, on average. Across the six ECs included in the cost analysis, there was substantial variation in cost, with some ECs costing less than traditional high schools and some ECs costing substantially more (\$2,000 to \$7,000 per student per year) than traditional high schools.

The ECs in this study typically cost less in terms of their school-level spending and spent substantially less on school-level instructional personnel compared with traditional high schools. However, they typically spent more on instructional nonpersonnel, such as textbooks. Lower levels of school-level spending were offset by the cost of college-level instruction and some additional administrative costs for districts with ECs as well as the colleges partnering with ECs.

Using average estimates for both costs and benefits, we found that the benefits greatly exceeded the cost of providing four years of EC instruction. We calculated an NPV of almost \$54,000 per student and a benefit–cost ratio of 15.1. The estimated NPV of the average estimates in this study is slightly less than the estimated NPV of over \$62,000 per participant and a benefit–cost ratio of 16.5 by WSIPP (2018) in its study of the benefits and costs of ECs.

The average estimate of public benefits alone exceeded cost by over \$20,000 per student, for a public benefit–cost ratio of 6.3. Even when using conservative estimates of both cost and benefits, we calculated an NPV of approximately \$27,000 per student and a benefit–cost ratio of 4.6.

To model the uncertainty of the estimates, we used an approach to simulate both average and conservative estimates of cost and benefits. The simulated estimates of the benefits of ECs exceeded the cost more than 99.9 percent of the time using average estimates and more than 99 percent of the time using conservative estimates. Even when considering public benefits only, the simulated average estimates of benefits exceeded simulated average estimates of cost more than 98 percent of the time.

Policy Implications

These findings portray a positive picture of ECs and indicate the strong probability that the benefits of ECs outweigh the costs. With a conservative benefit–cost ratio of 4.6 and an average benefit–cost ratio of 15.1, the return on investment of ECs is in the same ballpark as, and potentially larger than, other college readiness programs, such as the Talent Search TRIO program, which has an estimated benefit–cost ratio of slightly more than 5 (Bowden and Belfield 2015). The benefit–cost ratio is also comparable to the benefit–cost estimates of early childhood programs, which have benefit–cost ratios in the range of 9 to 11 (Barnett 1995; Reynolds et al. 2011). The findings indicate that ECs are likely to be more cost-effective than many other interventions that occur during high school. Levin and Belfield (2007), for example, compared the benefits and cost of five different interventions aimed at reducing high school dropouts; benefit–cost ratios in their study ranged from 3.5 to 1.5.

The findings of this study, supported by other studies, suggest that high school students and society at large would benefit from providing more college-level coursework that contributes toward earning postsecondary degrees. However, it should be emphasized that the students who participated in this study attended ECs 8 to 13 years ago. Since then, dual enrollment course-taking has rapidly expanded. From 2000 to 2016, for example, the number of students taking dual enrollment courses in Texas increased from less than 19,000 to more than 204,000 (Miller et al. 2018). Therefore, if this study were replicated using a contemporaneous cohort of ninth graders, it is possible the high school experiences of control students today would substantively differ from the high school experiences of the control students in the current study, which could potentially lead to different estimates of the relative benefits of ECs.

Directions for Future Research

Results of this study revealed substantial variation in costs across ECs. Some ECs in our study cost less than traditional high schools in the same or surrounding districts, whereas other ECs cost more. In particular, one EC that partnered with a state flagship four-year university had a particularly high cost relative to traditional high schools in the surrounding district. Variations in cost as well as in school design beg the question of whether the impact of ECs varies across schools. We might expect impacts to be stronger in the more resource-rich ECs, and that impacts differ for partnerships with four-year state flagship schools (perhaps with a greater impact on bachelor's degree completion) than partnerships with a community college (perhaps with a greater impact on associate's degree completion). With only six ECs included in the cost analysis and ten ECs included in the impact analysis, it was not possible for us to look at differential impacts across ECs. Better understanding of the heterogeneity in impacts across sites would allow us to refine our understanding of the relationship between benefits and costs. Despite the need for future research, this study makes an important contribution by being among the first studies to rigorously estimate benefits and costs of ECs.

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APPENDIX

Table A.1. The Steps in Which Monte Carlo Simulation Was Used and the Description of the Monte Carlo Simulation

Step	Description
Impact result simulation	Pick a randomly generated value from a normal distribution using the mean and standard errors of the actual estimated impacts to establish the normal distribution.
Benefit estimate simulation	<p>For private benefits: Pick six values from a log-normal distribution using the mean and standard deviations of the natural log of the six estimates of private benefits of postsecondary educational attainment to establish the log-normal distribution. This simulates the finding of estimates for private benefits from six random studies.</p> <p>For public benefits: Pick three values from a log-normal distribution using the mean and standard deviations of the natural log of the three estimates of public benefits of postsecondary educational attainment to establish the log-normal distribution. This simulates the finding of estimates for public benefits from three random studies.</p> <p>Average estimate: Calculate the mean of the six randomly selected private benefits estimates and three randomly selected public benefits estimates.</p> <p>Conservative estimate: Select the minimum estimate of the six randomly selected private benefits estimates and the minimum estimate of the three randomly selected public benefits estimates.</p>
Cost estimate simulation	<p>Pick six values from a normal distribution using the mean and standard deviation of the differences in cost from traditional high schools for the six Early Colleges included in the cost analysis to establish the normal distribution. Calculate the mean of the six randomly generated values.</p> <p>Average estimates: Use the mean and standard deviation of the midpoint cost difference estimates to establish the normal distribution.</p> <p>Conservative estimates: Use the mean and standard deviation of the upper bound cost difference estimates to establish the normal distribution.</p>

Table A.2. Estimated Private Monetary Returns of Postsecondary Education Attainment by Education Level from Six Studies

	Some College/ No Degree	Some College	Associate's Degree	Bachelor's Degree
Studies of Private Monetary Returns				
Agan (2013)	\$73,143		\$144,884	\$209,654
Avery and Turner (2012)				\$478,069
Hershbein and Kearney (2014)	\$144,556		\$289,111	\$629,850
Kim, Tamborini, and Sakamoto (2015)				\$343,656
McMahon (2009)				\$666,978
Tamborini, Kim, and Sakamoto (2015)				\$251,360
Studies of Public Monetary Returns				
Carroll and Erkut (2009)		\$62,759		\$186,911
McMahon (2009)				\$593,204
Trostel (2010)			\$114,762	\$229,525

Notes: For studies of private monetary returns: Estimates from Agan (2013) accounted for 30 years after college entry; Avery and Turner (2012) assumed 42 years of work experience; Hershbein and Kearney (2014) and Kim, Tamborini, and Sakamoto (2015) accounted for returns greater than 40 years; Tamborini, Kim, and Sakamoto (2015) estimated 50-year effects on lifetime earnings; McMahon (2009) reported a yearly average return, which was converted to lifetime earnings based on 40 years; Agan (2013) and Avery and Turner (2012) subtracted the cost of attending college from their estimates. For studies of public monetary returns: Carroll and Erkut (2009) included individuals with an associate's degree and those who attended college but did not graduate in their definition of some college; Carroll and Erkut (2009) estimated lifetime public returns from age 18 to 79; Trostel (2010) estimated lifetime public returns from age 19 to 79; McMahon (2009) reported a yearly average estimate of public returns, which was converted to lifetime earnings based on 40 years. Dollars are inflation-adjusted using the consumer price index to represent 2017 dollars.