The Costs and Benefits of Early College High Schools

DECEMBER 2019

Drew Atchison | Kristina L. Zeiser | Salma Mohammed | Jesse Levin
David Knight *University of Washington*

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Introduction

Postsecondary credentials are increasingly needed for upward mobility in the U.S. economy (Carnevale, Rose, & 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 & Dynarski, 2011; Duncheon, 2015, 2018). Early Colleges (ECs) represent an expanding college readiness reform that provides students an opportunity to earn up to 60 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, policymakers 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 10 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 6 years after expected high school graduation (Song & 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 how the costs of ECs compare with costs associated with a traditional high school education, as well as how the costs compare with the economic benefits of ECs. In addition to understanding whether educational interventions are effective, policymakers also need to understand whether interventions are efficient (Levin, McEwan, Belfield, Bowden, & Shand, 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.

This study complements an earlier AIR study of ECs that examines the impacts of ECs in substantial detail (Song & Zeiser, 2019). Here, to understand whether ECs are a worthwhile use of resources, we first examined the impact of enrollment in an EC on postsecondary attainment in a slightly different fashion than the prior study. We then calculated the lifetime benefits of ECs resulting from increased postsecondary attainment. In addition, we collected primary data on resource use from a set of the schools on which the impact estimates are based and used these data to estimate costs, comparing the per-student costs of ECs with the per-student costs of traditional high schools. Last, we compared the estimated lifetime benefit with cost to determine whether the benefit exceeds the cost.

Our results indicate that ECs increase students' likelihood of attending and graduating from college with an associate or bachelor's degree. The increased educational attainment attributed to EC enrollment results in average lifetime benefits of almost $58,000 per student. By comparison, the cost of ECs is approximately $955 more per student per year than traditional high school, or $3,800 per student for 4 years of high school; however, we observed substantial variation in the cost of ECs across sites (from a low of $2,279 less per student per year 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 with the cost, the result is a net present value (NPV) of approximately $54,000 per student and a benefit-to-cost ratio of 15.1. Even when using conservative estimates of the costs (upper bound) and benefits (lower bound) of ECs, we find that the benefits substantially outweigh the costs, with a benefit-to-cost ratio of 4.6.

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. Its explicit goal 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.

From 2002 to 2011, more than 240 ECs opened nationwide as part of the ECHSI (Jobs for the Future, 2013). Although many traditional high schools offer dual-enrollment opportunities, where students can enroll in college courses while in high school, the EC approach is much more intensive and offers more student supports. In addition, although dual enrollment is often provided as an option for higher achieving students, ECs provide these opportunities to all students.

Through the ECHSI, ECs partner with colleges and universities to offer enrolled students an opportunity to earn an associate degree or up to 2 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 (AIR & SRI International, 2008, 2009; Cassidy, Keating, & Young, 2010; Duffy, Cassidy, Keating, & Berger, 2009). 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 often is a barrier to college attendance for academically qualified students from low-income families (Bettinger, Long, Oreopoulos, & Sanbonmatsu, 2009; Hoxby & 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, Bailey, Constantine, Finkelstein, & Hurd, 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 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; Edmunds, Willse, Arshavsky, & Dallas, 2013; Edmunds et al., 2017) and AIR (Berger et al., 2013; Berger, Turk-Bicakci, Garet, Knudson, & Hoshen, 2014; Haxton et al., 2016). These studies found positive 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).

Although rigorous studies have examined the impact of ECs on student outcomes, few studies have examined the costs of ECs. Webb (2004) analyzed the budgets of six ECs to understand the planning and implementation costs of ECs and found substantial variation across different models of implementation. 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 on the campus of a 4-year university. The three models associated with 2-year colleges ranged from $9,200 to $11,200 per student.[1] 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 the cost of traditional high schools. Information about the additional costs associated with ECs, over and above the costs of a “business-as-usual” traditional comprehensive high school, is more relevant for policymakers 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

[1] Dollar figures were converted from 2004 dollars to 2017 dollars using the Consumer Price Index to adjust for inflation.

per semester credit hour of college courses taken. Because EC students take an average of 10 to 12 credits per year, that amounts to $1,100 to $1,320 more per student per year.

To our knowledge, only a single study to date has compared the economic benefits of ECs with the 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-to-cost ratio of 16.5. However, the approach taken by WSIPP (2018) 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 of ECs. Furthermore, the impact estimates used in the WSIPP study examine students through a maximum of 4 years after their expected high school graduation. As 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. Using impact results estimated with a longer time frame will produce more accurate estimates of benefits.

Research Questions and Purpose

This study examines postsecondary outcomes of students who participated in admission lotteries to 10 ECs 6 years after their expected high school graduation. By following students for 6 years after expected high school completion, this is the first study that follows students for a sufficient length of time (i.e., 150% of normal time to completion) to examine impacts on bachelor's degree completion. In addition to examining the impacts of EC on students' educational attainment, we conduct a social benefit-cost analysis, examining the comprehensive set of costs and benefits of EC inclusive of both public and private costs and benefits. We address the following research questions (RQs):

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 costs?

Policymakers 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, and then comparing the benefits with the costs of ECs, we provide valuable information to determine whether ECs represent a worthwhile educational investment.

Methodology

The methodology consists of four components relating to each of the four research questions. First, we measured the impact of ECs on students' postsecondary attainment. Second, we used the impact estimates, along with estimates of the monetary returns of postsecondary attainment, to estimate the benefits of ECs. Third, we calculated the costs of ECs relative to traditional high schools that non-EC students would have most likely attended. Last, we compared the benefits of ECs with the costs. Here, we present a brief overview of the methods. A more detailed description of the methods can be found in Appendix A.

Measuring the Impact of ECs

The impact analysis takes advantage of a multisite natural experiment with student-level random assignment. Specifically, we examined 10 ECs that (a) enrolled students in Grades 9–12, (b) had students who graduated high school by 2011, (c) used lotteries as part of their admission process for at least one incoming cohort for school years 2005–06 to 2007–08, (d) retained lottery records, and (e) implemented a whole-school EC program. The ECs included in the study were located in five states, predominately in 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. 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.

Using data on students' postsecondary experiences, we classified students based on their terminal outcome 6 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: (a) did not attend college, (b) attended some college without completing a degree, (c) completed an associate degree without completing a bachelor's degree, and (d) completed a bachelor's degree.

We then used multinomial logistic regression, which is used in cases where the outcome variable is a categorical variable with more than two outcomes, to estimate the likelihood of each outcome for EC students and those who did not attend an EC (i.e., non-EC students).[2] Additional details concerning the methods for measuring the impact of ECs can be found in Appendix A.

Converting Impact Estimates to Benefits

To convert the EC impacts on 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 (see Appendix B). 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, such as increased tax revenue and decreased spending on public services.

Using the identified studies, we generated two estimates of the monetary returns of postsecondary education: an average estimate and a conservative estimate. The average estimate combines all estimated returns of postsecondary education across studies into an average estimate for individuals who attend some college but do not earn a degree, who earn an associate degree, and who earn a bachelor's degree. The conservative approach safeguards against overestimating the returns by using the lowest estimate of the returns of 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 estimated percentages of students experiencing different postsecondary attainment outcomes between EC students and non-EC students (from the regression models described above) 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.

[2] As part of the impact analyses, we estimated the intent-to-treat effect, comparing students who won the lottery with those who did not win the lottery to attend Early Colleges (ECs). We then estimated the treatment-on-the-treated (TOT) effect using a two-stage estimation, comparing students who attended ECs with those who did not attend ECs. All models accounted for differences in student demographics and prior achievement as well as the clustering of students within lotteries. In this paper, we highlight the TOT estimates because discussing the financial benefits of attending ECs is more intuitive and meaningful than discussing the financial benefits of winning the lottery to attend ECs.

Calculating the Costs of ECs

Our aim was to determine the costs of ECs relative to other local traditional high schools that non-EC student most likely would have attended between 2005–06 and 2010–11, the years in which the students in our study attended high school. To do so, we used extant school-level spending data on the ECs in our sample and the traditional high schools in the same or neighboring school district of the ECs.[3] We supplemented these data with college spending data from the Integrated Postsecondary Education Data System (IPEDS) for colleges and universities partnering with the ECs in our sample to estimate the additional costs of instruction provided by colleges and universities for students taking dual-enrollment courses through the EC or traditional high schools. Last, we conducted interviews with administrators in colleges and school districts involved in administering EC and dual-enrollment programs to estimate the additional administrative costs of ECs at the college and district levels.

We estimated the total cost for ECs as well as traditional high schools in the same or surrounding district, consisting of the base costs (estimated using school-level expenditures), district and college administrative costs (estimated using data from interviews), and college instructional costs (estimated using IPEDS data). After identifying and summing all costs for ECs and traditional high schools, we 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 4 years, we calculated the total differential cost per student by multiplying the yearly difference by four. We used alternative assumptions about college instructional costs to represent different levels of uptake of college services by high school students taking dual-enrollment courses to calculate 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. Additional detail regarding the calculation of costs can be found in Appendix A.

Comparing Costs and Benefits

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

[3] When ECs were part of a school district, we used the traditional high schools in the same district. Some ECs were charter schools or otherwise independent of any school district. In these cases, we used traditional high schools in the closest neighboring school district.

both conservative costs (that err on the high side) and conservative benefits (that err on the low side), to identify a plausible lower bound of the NPV and benefit-to-cost ratio.

Last, we compared benefits with costs, separating benefits according to whether they are private or public. Specifically, because most of the associated cost of ECs are funded through public tax dollars, policymakers might place more value on the benefits accrued by the public rather than the benefits to individual students. The comparison of public benefits with costs identifies whether the general public receives benefits that exceed the costs of investing in ECs.[4]

Results

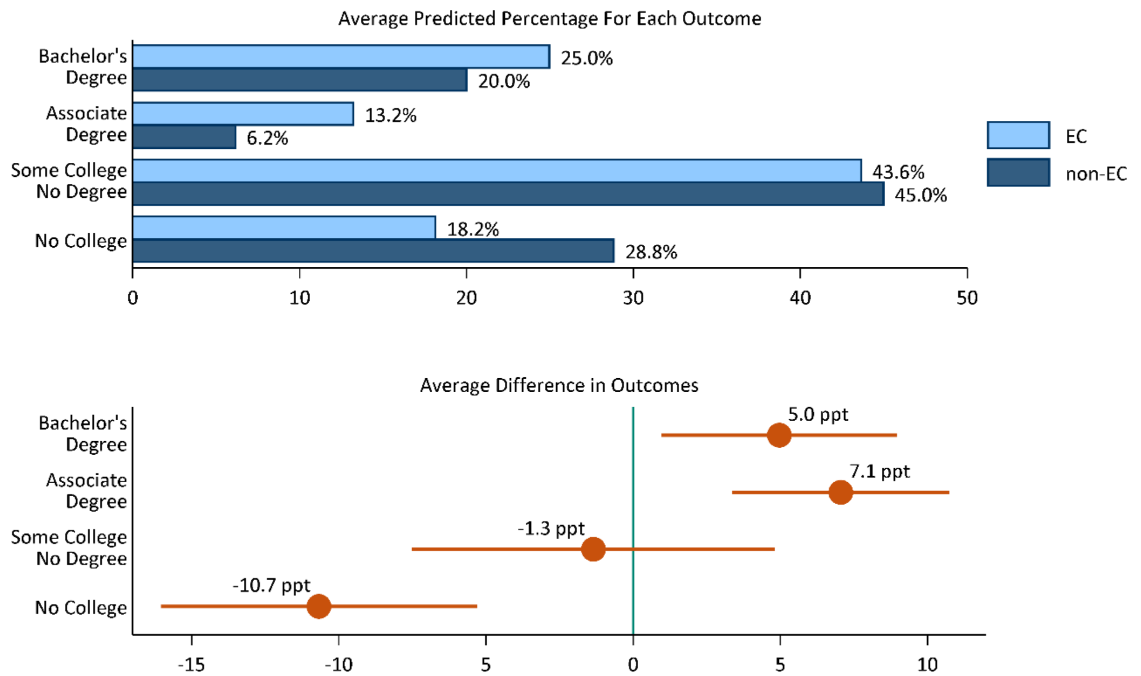
Here, we present the results of each of the study components, starting with the impact estimates, followed by benefit and cost estimates, and concluding with the comparison of benefits and costs.

The Impact of ECs on Postsecondary Outcomes

As shown in Figure 1, our estimates of the impact of ECs indicate that students who attended ECs were significantly more likely than those who did not attend ECs to complete a bachelor's degree (25.0% vs. 20.0%) or associate degree (13.2% vs. 6.2%). In contrast, students who attended ECs were significantly less likely than those who did not attend ECs to not have gone to college at all (18.2% vs. 28.8%). EC students and non-EC students are approximately equally likely to have attended some college but not earned a degree within 6 years after expected high school graduation. For more detail regarding the impact analysis results, see Appendix B.

[4] As a supplemental exercise, we modeled the uncertainty of the estimated net present values to estimate the likelihood that benefits exceed costs. This is akin to providing a confidence interval around statistical estimates. Additional information regarding modeling of uncertainty of our benefit-to-cost estimates can be found in Appendix A.

Figure 1. Estimates of the Impact of Early College Enrollment on College Enrollment and Completion Outcomes, 6 Years After Expected High School Graduation



Notes. N = 2,458 (1,044 EC students; 1,414 non-EC students). ppt = percentage points. 95% confidence intervals on the estimated average difference are shown in the lower panel of the figure. The estimates presented here are the treatment-on-the-treated estimates. We present additional impact results in Appendix B that include intent-to-treat estimates.

The Benefits of ECs

Using studies examining the monetary returns of postsecondary education, we estimated the benefits attributable to EC impact on postsecondary attainment. In our estimation of benefits, we used both an average estimate of the returns of postsecondary education, where we averaged across all studies, and a conservative approach, using the smallest returns of postsecondary education reported across studies. The conservative estimates of the returns of postsecondary attainment are slightly more than half as large as the average estimates. Across the set of studies, private returns of a bachelor's degree amount to approximately $392,000, on average, while the most conservative estimate of private returns of a bachelor's degree is approximately $210,000. Public returns of a bachelor's degree amount to $294,000, on average, and $187,000 conservatively. For more detail on the estimated returns of postsecondary education used in the estimation of benefits, see Appendix B.

Table 1 presents the benefits attributable to enrolling in an EC. These are the returns of postsecondary attainment multiplied by the estimated impacts of ECs. The 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.

Table 1. 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

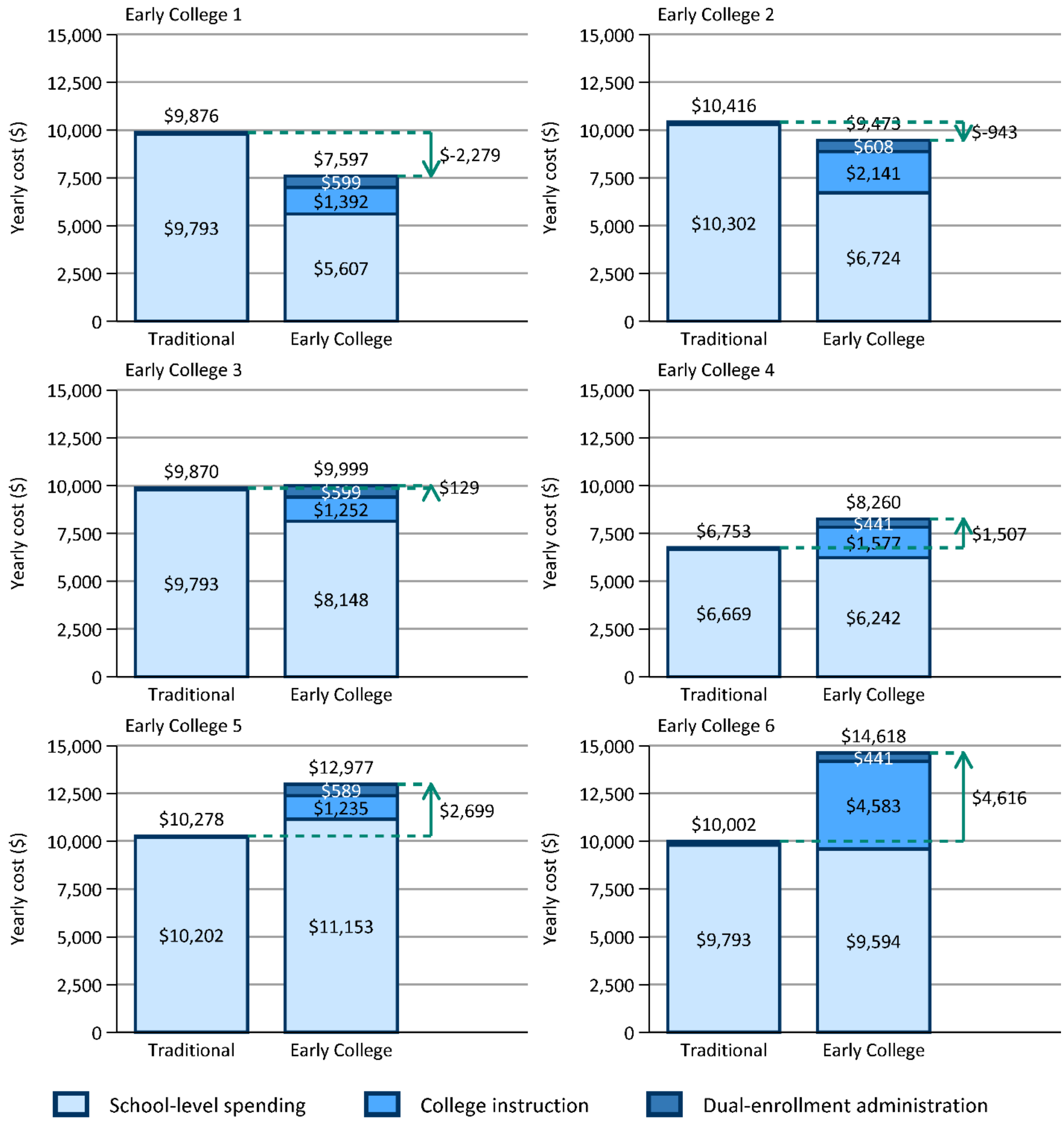
Note. Dollars are inflation adjusted using the Consumer Price Index to represent 2017 dollars. Estimated benefits are the product of the estimated difference in postsecondary outcomes between EC and traditional students and the estimated returns of postsecondary education.

The Costs of ECs

Figure 2 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 school; (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 costs 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 courses in ECs because students in ECs earned a greater number of college credits compared with students in non-EC high schools. The college instructional costs presented in Figure 2 represent our preferred estimates (the midpoint between the lower and upper bounds). It also should be noted that administrative costs do not account for general district administration, which is assumed to be the same for both EC and traditional high school students, and do not represent school administrative costs, which are captured by school-level spending.[5]

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

Figure 2. Estimated Costs of Traditional Comparison High Schools and Early Colleges



Note. Dollars are inflation adjusted using the Consumer Price Index to represent 2017 dollars. College instructional and administrative costs are included on the traditional side but are not labeled because of the small amount. Administrative costs represent only the incremental district and college administrative costs associated with dual enrollment or EC.

For traditional high schools, almost all costs consist of school-level spending. Only a small fraction of costs 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 costs associated with administering dual-enrollment or EC programs on either the district or 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, which is based on data from Texas that non-EC students take 0.5 credits per year on average (because only a subset of students in traditional high schools elect to take dual-enrollment courses) 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.[6]

The difference between EC 6 and its average traditional high school cost appears to be particularly large, with estimated differences ranging from $2,241 to $6,991, depending on how college instructional cost is estimated. As shown in Figure 2, the difference 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 costs at any of the other ECs, which is explained in large part by the fact that EC 6 partnered with a state flagship 4-year public university. Three of the other six ECs partnered primarily with community colleges. The remaining ECs partnered with a 4-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 4-year university is consistent with the findings from previous research (Webb, 2004).

The results presented in Figure 2 illustrate large variation in EC costs within the study sample, with a minimum per-student cost of $7,597 (EC 1) and a maximum per-student cost of $14,618 (EC 6). In contrast, with the exception of one average traditional high school cost of $6,753 per student (traditional high schools surrounding EC 4), the average per-student cost of traditional schools in the sample ranged from $9,870 (traditional high schools surrounding EC 3) to $10,416 (traditional high schools surrounding EC 2). As a result, we also observed variation in differences in per-student costs between ECs and their neighboring traditional high schools.

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

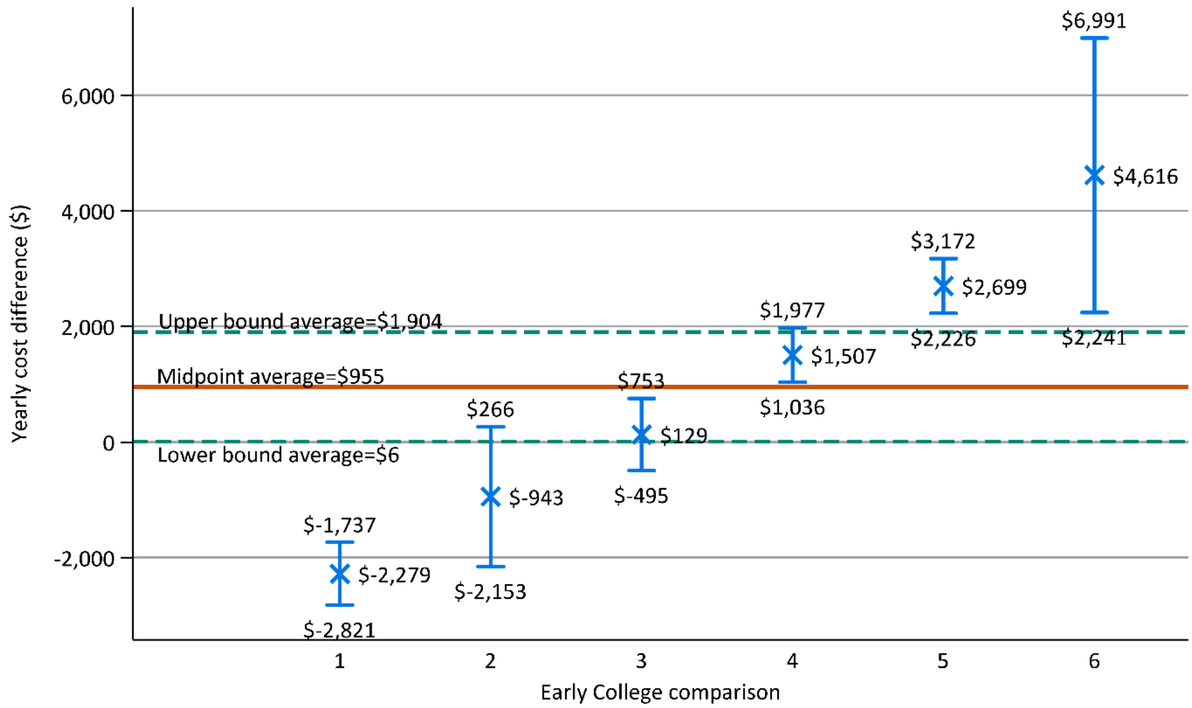
[6] This assumption of the number of credits taken for traditional high school students and EC students is calculated based on administrative data of dual-enrollment credits taken by Texas high school students. In addition, the goal of completing a 2-year credential during high school would suggest that students would need to take 15 credits per year to complete the 60 credits required for a 2-year degree within the 4 years of high school.

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 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 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 3. For each EC, we present the lower bound, midpoint, and upper bound of the cost difference calculated using the different definitions of college instructional cost.[7] In addition, Figure 3 shows the average of the lower bound, midpoint, and upper bound differences across sites. The lower bound average difference indicates that ECs cost only $6 more per student per year than traditional high schools, whereas the upper bound average difference indicates that 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 EC 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 as students in their data took 10–12 credits per year, on average, which is slightly higher than our average estimate but less than our conservative (upper bound) 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.

[7] Lower bound estimates of college instructional costs account only for instructor salaries and benefits, and they make the assumption that most EC students are not taking full advantage of all academic and instructional resources that colleges or universities may offer (e.g., library, tutoring, academic advising from college staff). Upper bound estimates of college instructional costs account for all instructional and academic activities that students may access and make the assumption that EC students utilize all resources in the same manner as typical college students.

Figure 3. Lower Bound, Midpoint, and Upper Bound Estimates of Yearly Cost Differences Between Early College and Traditional High Schools



Note. Dollars are inflation adjusted using the Consumer Price Index to represent 2017 dollars.

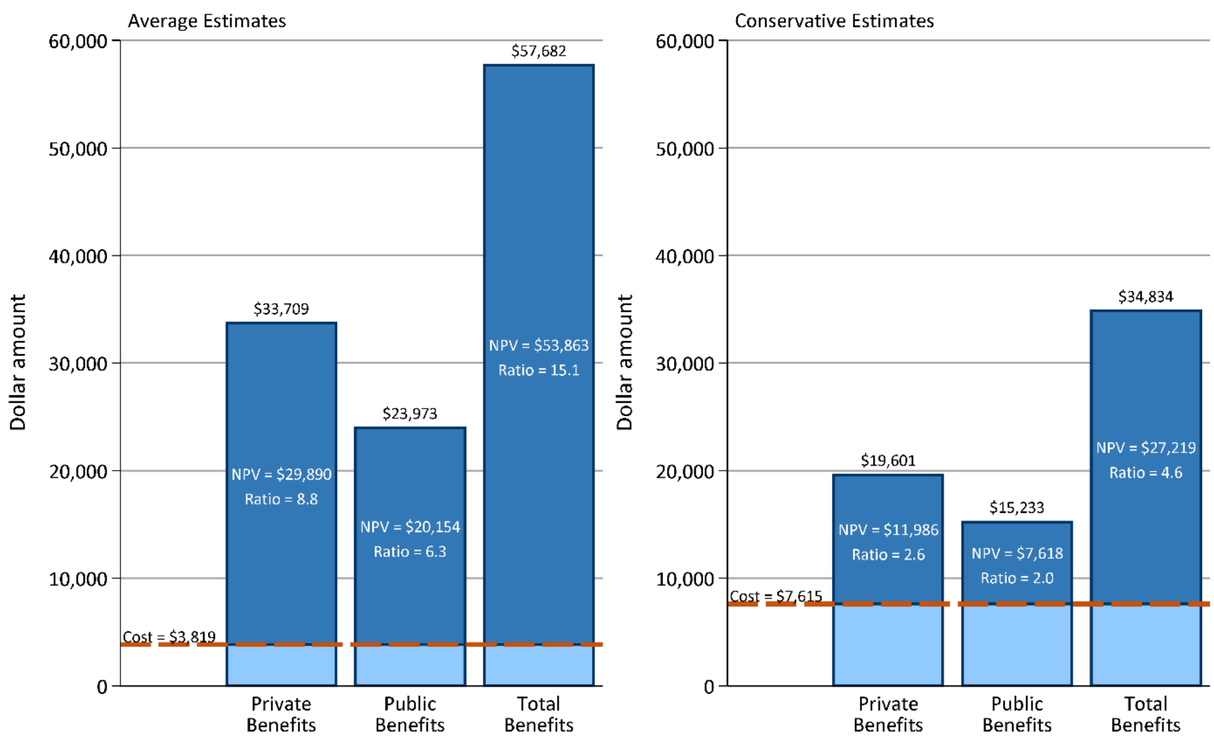
The Benefits to Costs of ECs

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, while the conservative estimates will result in lower bound estimates of the NPV and benefit-to-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 4 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 traditional high schools in our study.[8] 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.

[8] Some Early Colleges (ECs) operate as 5-year programs; however, all of the ECs included in the cost analysis portion operated as 4-year programs.

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-to-cost ratio is 15.1. In other words, using the average estimates of benefits and costs, we found that benefits are more than 15 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-to-cost ratio of 8.8. Accounting only for public benefits, the NPV using average estimates is $20,154 per student, and the benefit-to-cost ratio is 6.3.

Figure 4. Comparison of Average and Conservative Estimates of Costs and Benefits of Early Colleges



Note. Dollars are inflation adjusted using the Consumer Price Index to represent 2017 dollars. The NPV (net present value) is the difference between benefits and costs. The ratio represents the benefits divided by costs. The dark-blue portion of the bars is the portion of benefits that are above and beyond the costs. Therefore, the dark-blue portion represents the NPV.

Our conservative estimates use the upper bound average yearly difference of costs ($1,904). Multiplied by four, to account for 4 years of high school enrollment, the conservative cost estimate is $7,615 per EC student. Conservatively estimated private benefits of EC are $19,601 per student, public benefits are $15,233 per student, and total benefits are $34,834 per student.

Using conservative estimates of costs and total benefits, the NPV is $27,219, for a benefit-to-cost ratio of 4.6. Using only the public portion of benefits, we calculate a conservative NPV of $7,618 and a benefit-to-cost ratio of 2.0. Therefore, even when using what we consider to be conservative estimates of benefits and costs, the total benefits are 4.6 times the cost, and public benefits alone are two times the cost. For more sensitivity testing examining the likelihood that benefits of ECs outweigh the benefits (a positive NPV) and showing the range of plausible NPVs of ECs, see Appendix B.

Conclusions

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 benefit-to-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 degree or a bachelor's degree. Using existing studies that quantified the monetary private and public returns of 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 nearly $34,000 of benefits going to the individual student and approximately $24,000 of benefits going to the public at-large. Using conservative estimates of the returns of 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 the cost of surrounding traditional high schools for six ECs. Averaged across the six ECs, our preferred estimate indicated that ECs cost $955 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 actually costing less than nearby traditional high schools and other ECs costing substantially more ($2,000 to $7,000 per student per year) than nearby 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 generally spent more on instructional nonpersonnel resources, 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 4 years of EC instruction. We calculated an NPV of almost $54,000 per student and a benefit-to-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-to-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 costs by over $20,000 per student, for a public benefit-to-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-to-cost ratio of 4.6.

Policy and Research Implications

These findings portray a positive picture of ECs and indicate a strong probability that the benefits of ECs outweigh the costs. With a conservative benefit-to-cost ratio of 4.6 and an average benefit-to-cost ratio of 15.1, the economic returns of ECs are in the same ballpark as, and potentially larger than, other college-readiness programs, such as the TRIO Talent Search program, which has an estimated benefit-to-cost ratio of slightly more than 5 (Bowden & Belfield, 2015). The benefit-to-cost ratio also is comparable to those of early childhood programs, which have benefit-to-cost ratios of 9 to 11 (Barnett, 1995; Reynolds, Temple, White, Ou, & Robertson, 2011). The findings indicate that ECs are likely to be more cost effective than many other educational interventions.

The findings of this study suggest that both high school students and society at-large would benefit from college-level coursework and the associated academic supports provided at ECs. However, it should be emphasized that the students who participated in this study attended ECs 8 to 14 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 that 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.

Results of this study also 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 4-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 4-year state flagship schools (that may have a greater impact on bachelor's degree completion) than partnerships with community college (that may have a greater impact on associate degree completion). With only six ECs included in the cost analysis and 10 ECs included in the impact analysis, it was not possible for us to look at differential impacts across ECs. A 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 made an important contribution by being among the first studies to rigorously estimate benefits and costs of ECs.

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Appendix A. Detailed Methodology

Here, we provide an overview of the methods for the various components of this study, including measuring impacts, converting impacts to estimates of benefits, calculating costs, comparing costs and benefits, and modeling uncertainty.

Measuring the Impact of Early Colleges (ECs)

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 also was confirmed by examining baseline equivalence between students who won the EC admissions lottery and students who did not win the admissions lottery (see Table A1). There were no statistically significant differences at conventional levels of statistical significance in the probability of being female, non-White, 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. The average characteristics of the treatment group, shown in Table A1, 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% of the treatment group were eligible for free or reduced-price lunch) and were mostly non-White (51.8% of the treatment group).[9] The students in the sample also tended to be higher performing than average students in their respective states, performing more than 0.2 standard deviations above the state average on their eighth-grade ELA and mathematics assessments.

Table A1. Treatment Group Characteristics and Baseline Equivalence Tests

Student Characteristic	Treatment Group Average	Estimated Treatment Group Difference	*P*-Value
Female	51.4%	-1.68 ppt	0.483
Non-White	51.8%	-0.35 ppt	0.819
Low income	49.4%	2.88 ppt	0.228
First-generation college going	23.9%	0.98 ppt	0.704
Grade 8 English language arts (ELA) test score	0.212 SD	0.07 SD	0.077
Grade 8 mathematics test score	0.227 SD	-0.01 SD	0.889

Notes. N = 2,458 (1,044 treatment, 1,414 control). ppt = percentage points. SD = standard deviations. The treatment group averages represent the unadjusted means. 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

[9] In contrast, nationwide, 55.8% of students were White and 42.4% were eligible for free or reduced-price lunch in the 2006–07 school year (Snyder & Dillow, 2010). However, the set of high schools in nearby districts that most control students attended served higher proportions of minority and low-income students than the Early Colleges (Berger et al., 2013).

estimated treatment group difference is the coefficient on the treatment indicator variable. Grade 8 ELA and mathematics test scores represent standard deviation differences from respective state means.

Given that the outcome of interest has four mutually exclusive categories (i.e., did not attend college, attended some college without completing a degree, completed an associate degree without completing a bachelor's degree, and completed a bachelor's degree within 6 years of expected high school graduation), we estimated the EC impact on this outcome using multinomial logistic regression. 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 conservative in nature.

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.[10] In other words, we used acceptance by lottery as an instrument for EC enrollment. In this way, we isolated the random variation in enrolling in ECs due to acceptance by lottery to generate internally valid estimates of the impact of EC enrollment.

To ensure that the observed differences between EC students and non-EC students do not drive EC impact estimates, both the ITT and TOT models controlled for student gender, student race, whether the student's parents had attended college, eighth-grade math and ELA test scores, and free or reduced-price lunch status. Last, 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 by lottery and the treatment condition was being accepted to attend an EC by 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

[10] Enrollment in this case is an indicator of whether a student enrolled in the Early College (EC) during their ninth-grade year. Students could have attended the EC during ninth grade, but transferred to another high school in later school years. Because of this, even the treatment-on-the treated (TOT) estimates are likely more conservative than the impact of attending an EC throughout high school.

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.

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 EC, can be found in Song and Zeiser (2019).

Calculating the Cost of ECs

Our aim was to determine the cost of ECs relative to other local traditional high schools that 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. We used a hybrid approach to the cost analysis, relying on a combination of data sources. [11]

Because ECs represent a whole-school model, rather than an add-on program, we defined the incremental cost of ECs as the difference between 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 spending attributed to individual schools. We used these data to establish a base cost of each EC and all of the traditional high schools in the same district.[12] Because we were able to collect school-level spending data from six of the 10 ECs included in the impact analysis, our cost estimates are based on those six ECs.[13]

Although school-level spending data are a useful starting point, these data do not sufficiently capture instructional or administrative resources incurred at institutions of higher education (IHEs). In particular, schools or districts often are charged tuition by IHEs 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 the

[11] 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 7–12 years prior to the current study posed unique challenges for adopting this approach.

[12] We assume that school-level expenditure data provide a rough approximation of the cost to operate an Early College (EC) and a traditional high school, while recognizing that production inefficiencies may cause expenditures to exceed the actual cost.

[13] Because each agency collects and reports spending data in different ways, we were limited in the level 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.

full tuition amount for dual-enrollment programs, including EC. 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 EC and the cost of instruction provided by IHEs.[14]

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.[15] From these interviews, we identified the 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.[16]

To understand the cost of administering EC that IHEs incur, 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, 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 regarding the actual level of college resources used by EC students expressed by college administrators in interviews, we calculated two versions of college instructional costs to represent lower and upper bounds on the estimates. The lower bound estimate of instructional costs includes only the costs of instructor salaries and benefits. The upper bound estimate captures all instructional costs per student incurred at

[14] 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.
[15] We found that most administrators in school districts or colleges did not place much distinction between Early College (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.
[16] 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.

a particular college (e.g., libraries, computer labs, tutoring services) and treats EC students the same as other students attending a given college or university.

Using the described data sources, we estimated the total cost for ECs as well as for traditional high schools in the same or surrounding district, consisting of the base costs, district administrative costs, college administrative costs, and college instructional costs. After identifying and summing all costs for ECs and traditional high schools, we converted the total cost to the cost per pupil. To measure the differential yearly cost associated with ECs, we subtracted the average traditional high school cost from the EC cost. Assuming that individual students attend ECs and traditional high schools for 4 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.

Modeling Uncertainty

Because of the small number 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-to-cost analysis. Table A2 provides descriptions of how randomly generated numbers were used to simulate impact results, benefits, and cost.

After generating random estimates of the impact results, the benefits of postsecondary attainment, and the costs of ECs above the costs of traditional high schools, we estimated the benefits attributable to ECs by multiplying the randomly generated impact results with the randomly generated benefits of postsecondary attainment. We then estimated the net present value (NPV) by calculating the difference between the randomly generated 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.

Table A2. 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	**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. **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. **Average estimate:** Calculate the mean of the six randomly selected private benefits estimates and three randomly selected public benefits estimates. **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.
Cost estimate simulation	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 ECs included in the cost analysis to establish the normal distribution. Calculate the mean of the six randomly generated values. **Average estimates:** Use the mean and standard deviation of the midpoint cost difference estimates to establish the normal distribution. **Conservative estimates:** Use the mean and standard deviation of the upper bound cost difference estimates to establish the normal distribution.

Appendix B. Detailed Results

The Impact of Early Colleges (ECs)

The intent-to-treat (ITT) impact estimates are presented in Table B1. 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 each of the three outcome categories, indicating that students who were accepted to an EC through the admissions 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 degree but not a bachelor’s degree, and to have earned a bachelor’s degree, relative to not attending college.

Table B1. Intent-to-Treat Estimates of the Impact of Acceptance to an Early College on College Enrollment and Completion Outcomes, 6 Years After Expected High School Graduation

	Multinomial Logit Coefficient	Average Predicted Probabilities		Average Marginal Effect
		Not Accepted by Lottery	Accepted by Lottery	
No college	(omitted)	28.3%	21.1%	-7.2 ppt***
		(1.129)	(1.420)	(1.926)
Some college/no degree	0.329**	44.9%	43.7%	-1.2 ppt
	(0.127)	(1.366)	(1.636)	(2.255)
Associate degree/no bachelor’s	1.030***	6.5%	11.2%	4.7 ppt***
Degree	(0.195)	(0.714)	(0.909)	(1.205)
Bachelor’s degree	0.659***	20.3%	24.1%	3.7 ppt*
	(0.158)	(1.100)	(1.128)	(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. Asterisks denote a statistically significant difference from zero. *** $p < .001$; ** $p < .01$; * $p < .05$.

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

Although the ITT estimates provide information about the impact of winning an EC admissions lottery, the TOT estimates are perhaps more relevant for policymakers because they show the specific impact of attending an EC compared with a traditional comprehensive high school. These estimates are presented in Table B2. The first-stage estimates indicate that students who were accepted to an EC by lottery were significantly more likely to enroll in an EC. Students accepted to an EC by lottery are predicted to have enrolled in an EC in ninth grade 70.5% of the time. In contrast, students not accepted to an EC by lottery are predicted to have enrolled in an EC only 3% 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 relative risk of enrolling in college, earning an associate degree, and earning a bachelor's degree, relative to 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 degree, and a 5.0 percentage point increase in the likelihood of earning a bachelor's degree. The average marginal effects on not attending college, earning an associate degree, and earning a bachelor's degree are all statistically significant at $p < .05$.

Table B2. Two-Stage Treatment-on-the-Treated Estimates of the Impact of Early College Enrollment on College Enrollment and Completion Outcomes, 6 Years After Expected High School Graduation

First-Stage Estimates (effect of being accepted by lottery on EC enrollment)				
		Average Predicted Probabilities		
	Logit Coefficient	Not Accepted by Lottery	Accepted by Lottery	Average Marginal Effect
EC enrollment	6.290***	3.0%	70.5%	67.5 ppt***
	(0.543)	(0.702)	(1.953)	(2.010)
Second-Stage Estimates (effect of EC enrollment on postsecondary attainment)				
		Average Predicted Probabilities		
	Multinomial Logit Coefficient	Did Not Attend EC	Attended EC	Average Marginal Effect
No college	(omitted)	28.8%	18.2%	-10.7 ppt***
		(1.309)	(1.995)	(2.740)
Some college/no degree	0.515**	45.0%	43.6%	-1.3 ppt
	(0.196)	(1.458)	(2.209)	(3.147)
Associate degree/no bachelor's degree	1.481***	6.2%	13.2%	7.1 ppt***
	(0.292)	(0.743)	(1.441)	(1.881)
Bachelor's degree	0.949***	20.0%	25.0%	5.0 ppt*
	(0.203)	(1.125)	(1.497)	(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, eight-grade math and English language arts test scores, and free or reduced-price lunch status. The regression models also include lottery (year by early college) fixed effects. Asterisks denote a statistically significant difference from zero. *** $p < .001$; ** $p < .01$; * $p < .05$.

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 Table B3). 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 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 (2013), for example, measured returns only for the first 30 years after college entry. Assuming college entry at age 18, this would account for returns accrued to individuals through age 48. Hershbein and Kearney (2014) measured returns across 40 years. McMahon (2009) reported an average yearly return of $31,000 per year after completing college. When converting this average yearly return to an NPV across 40 years, it amounts to $666,978.

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 22% 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 Table B3). 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 (2009) and Trostel (2010) ($186,911 and $229,525, respectively).

Table B3. Estimated Private and Public Monetary Returns of Postsecondary Education Attainment by Education Level

	Some College/No Degree	Some College	Associate 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

Note. 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 et al. (2015) accounted for returns greater than 40 years; Tamborini et al. (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 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.

Given the wide range of returns estimated by various studies, we used two different estimates of the returns of postsecondary education to calculate the benefits of ECs: an average and a conservative estimate. For the conservative estimate, 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 degree. Table B4 shows the average and conservative estimates of the returns of postsecondary attainment that we applied to our analyses.[17]

[17] 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 with the true level of benefits.

Table B4. 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 & Erkut, 2009)
Some college/no degree	$112,518	$73,535	$73,143	$46,728
Associate degree/no bachelor's degree	$223,948	$147,071	$144,884	$93,456
Bachelor's degree	$392,158	$294,143	$209,654	$186,911

Note. 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 degree or a bachelor's degree, benefits were assumed to decrease at a constant rate. Specifically, private returns of an associate degree were assumed to be 57.5% 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 degree and bachelor's degree benefits. The ratio of some college/no degree to associate degree private benefits was assumed to be 50.2%, the average ratio for studies including both categories of private benefits. The ratio of public returns of an associate degree to a bachelor's degree was assumed to be 50%, as was the ratio of public returns of some college/no degree to an associate degree. Note that for Carroll and Erkut (2009), the 50% ratio was applied to the returns of a bachelor's degree to estimate returns for some college/no degree and associate 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 degrees with some college/no degree, suggesting the 50% ratio is a reasonable assumption.

The Costs of ECs

To better understand the differences in the school-level spending cost component between EC and traditional high schools, we conducted a detailed comparison of the school-level spending data for three sites where EC and traditional high school spending was reported in the same format. Figure B1 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).

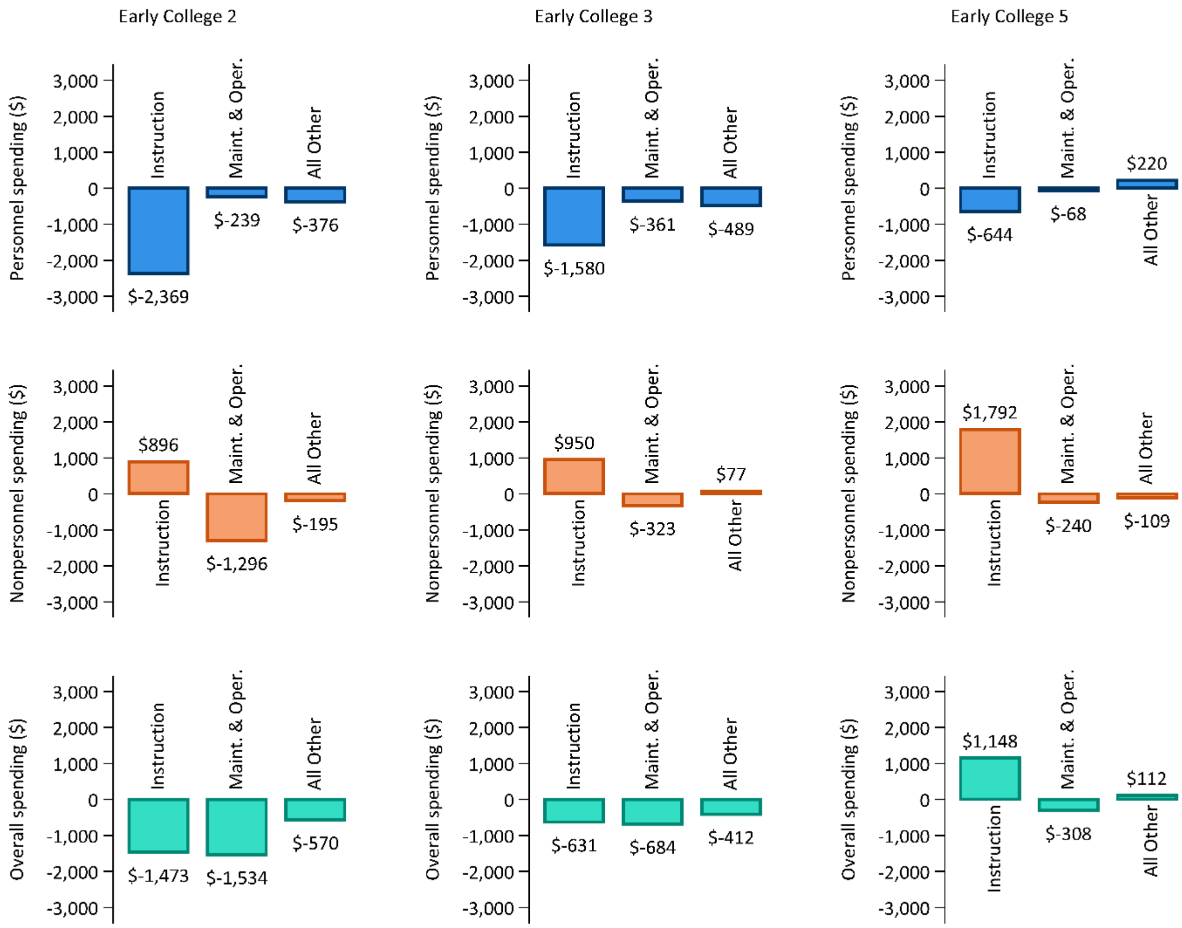
Looking at overall spending, in all three sites, spending on facility maintenance and operations was the category where traditional high schools most outspent ECs (represented by negative values), indicating that ECs save on school operational facility costs compared with traditional high schools.[18] In Early Colleges 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 Early College 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 Early Colleges 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 Early College 5, however, the positive difference in nonpersonnel instructional costs was larger in magnitude than the negative difference in personnel spending, leading to higher 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 more on nonpersonnel instructional costs.[19] However, as we observed in Figure 2 in the main text, 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.

[18] It should be noted, however, that we did not attempt to measure the possible increase in facilities costs to colleges resulting from Early College (EC) partnerships.

[19] 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 due to the savings on school-level personnel costs that result from students taking courses taught by college faculty.

Figure B1. Differences in School-Level Spending Between Early Colleges and Traditional High Schools by Spending Function



Note. Dollars are inflation adjusted using the Consumer Price Index to represent 2017 dollars.

Sensitivity Testing and Modeling Uncertainty

Simulations

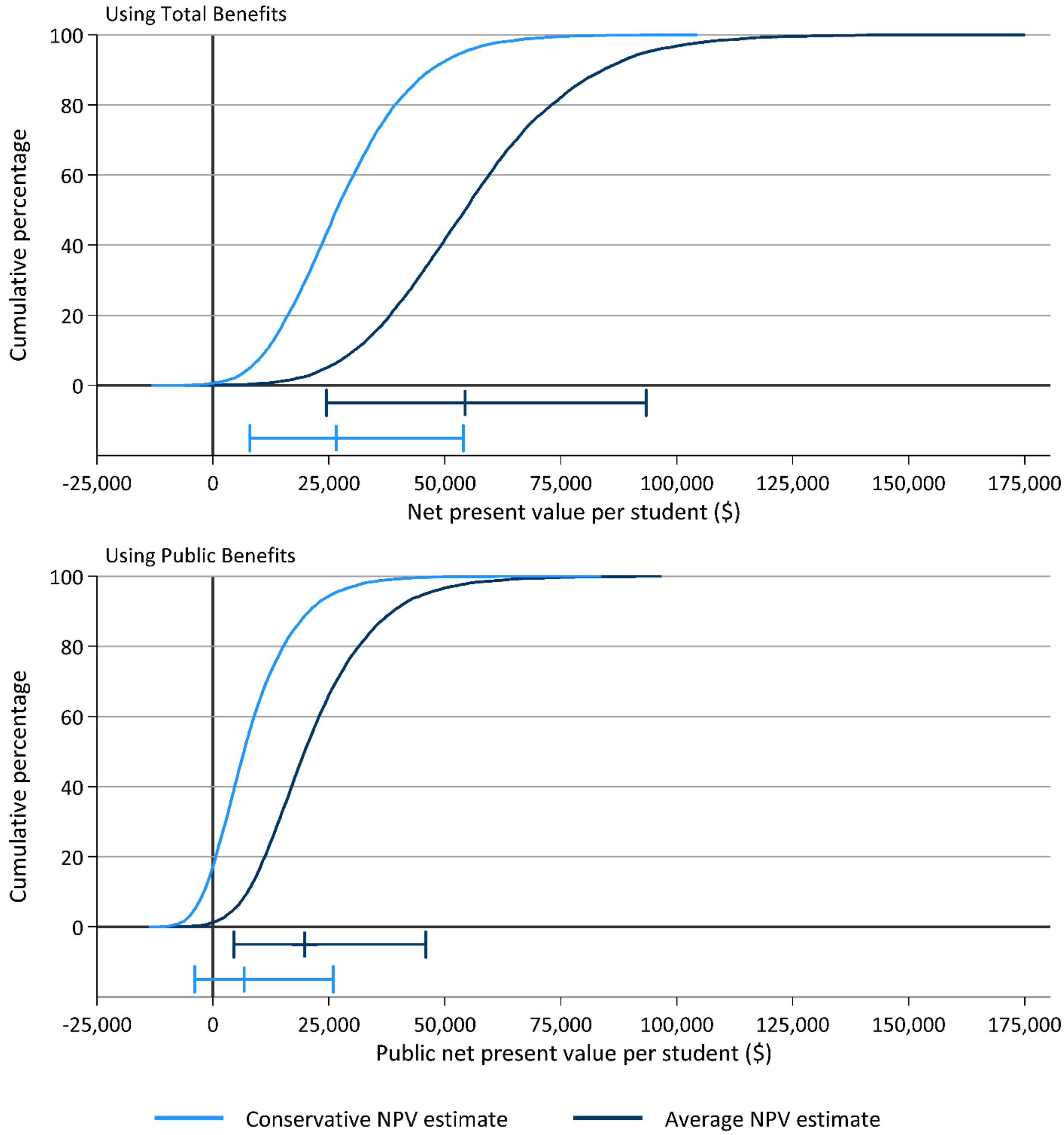
Figure B2 displays the results of the simulated NPV estimates. The top panel of the figure uses total benefits (private and public combined), and the bottom panel uses only public benefits. The curved lines in the figures represent cumulative percentages of the simulated estimates. Any point on the curved lines shows the percentages 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 looking at total benefits, less than 0.1% of average simulated NPVs fell below zero.[20] 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% of the resulting simulated NPV estimates were positive, and less than 1% 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% 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% of the time. The simulated conservative estimates of the public NPV were less than zero approximately 17% of the time. This exercise in modeling uncertainty indicates a strong likelihood that the benefits of EC exceed the costs.

[20] Five percent is the threshold for what we might consider statistically significant.

Figure B2. Monte Carlo Simulation Results for the Net Present Value



Note. Dollars are inflation adjusted using the Consumer Price Index to represent 2017 dollars. Horizontal range bars at the bottom of the figure depict the 5th to 95th percentile range as well as the median estimate.

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