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Marginal Effects of Merit Aid for Low-Income Students

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ABSTRACT

Financial aid from the Susan Thompson Buffett Foundation (STBF) provides exceptionally generous support to a college population similar to that served by a host of state aid programs. In conjunction with STBF, we randomly assigned aid awards to thousands of Nebraska high school graduates from low-income, minority, and first-generation college households. Randomly-assigned STBF awards boost bachelor's (BA) degree completion for students targeting four-year schools by about 8 points. Degree gains are concentrated among four-year applicants who would otherwise have been unlikely to pursue a four-year program. Degree effects are mediated by award-induced increases in credits earned towards a BA in the first year of college. The extent of initial four-year college engagement explains heterogeneous effects by target campus and across covariate subgroups. Most program spending is a transfer, reducing student debt without affecting degree attainment. Award-induced marginal spending is modest. The projected lifetime earnings impact of awards exceeds marginal educational spending for all of the subgroups examined in the study. Projected earnings gains exceed funder costs for low-income, non-white, urban, and first-generation students, and for students with relatively weak academic preparation.

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1 Introduction

American governments and private organizations spent $187 billion on financial aid to U.S. undergraduates in 2018. Government grant aid amounted to about $3,700 per full-time undergraduate, while private and institutional grants came to almost $6,000 per student.[1] It is unclear whether this vast expenditure increases college enrollment and completion. Evidence on aid effects is scarce for at least two reasons. First, aid decisions are confounded with student characteristics like family background and ability. Second, naturally-occurring variation in aid rules typically changes aid packages by only a few hundred dollars. It's hard to say whether the response to such modest changes predict those of withdrawing or adding major aid programs.

This paper assesses the effects of grant aid on degree completion in the context of a randomized field experiment that allocated exceptionally generous scholarships to 3,700 high school seniors graduating between 2012 and 2016. This experiment was conducted in partnership with the Susan Thompson Buffett Foundation (STBF), which funds about eleven percent of Nebraska high school seniors who go on to attend a Nebraska public college.[2] Characterized by modest merit cutoffs, a focus on applicants to public colleges, and strict family income eligibility caps, the STBF program targets an economically-disadvantaged population judged capable of college-level work. Three-quarters of those in the experimental sample are eligible for need-based federal Pell grant aid, one-third are nonwhite, and fewer than a third have a parent with a bachelor's degree. STBF awards are unusually generous and comprehensive, paying college costs for up to five years at any Nebraska public four-year college and up to three years at any Nebraska two-year college. Because STBF grant aid can be applied to any part of a student's total cost of attendance—tuition, fees, books, room and board, personal expenses, and transportation—STBF awards are offset little by clawbacks or caps that affect other sorts of aid.

For whom and by how much does STBF aid boost degree completion? Random assignment of STBF awards shows that aid boosts six-year BA completion rates for students targeting four-year schools by about 8 points (on a base of 63 percent). Degree gains are concentrated in groups of

[1]These statistics are from `https://research.collegeboard.org/trends/student-aid/figures-tables`. The federal government also loaned an average of $4,410 per undergraduate in 2018.

[2]Authors' calculations from data obtained from STBF and Coordinating Commission for Postsecondary Education (2013).

four-year applicants who are unlikely to have otherwise enrolled in four-year programs and who have low predicted four-year completion rates. This inverse relationship between baseline expected completion rates and the causal effect of aid on BAs is not a simple ceiling effect: even in applicant groups with the highest predicted completion rates, degree attainment is far from certain. Aid to applicants targeting two-year schools does not increase associate degrees but may increase BAs. The latter effect is positive but small, and not significantly different from zero.

Our analysis explains degree gains for four-year targeting applicants with the aid of a simple causal model. Specifically, we show that degree effects appear to be explained by the effect of awards on credit units earned towards a BA in the first year of study. In other words, aid is effective when it promotes early and deep engagement with a four-year college program. This "early engagement" mediator accounts for heterogeneous effects by target campus (e.g., whether a student targets a University of Nebraska campus in Omaha or Lincoln) and across covariate subgroups defined by characteristics like race and ACT scores. Outside of the early engagement channel, aid is unrelated to completion. In the language of instrumental variables (IV), endogenous early engagement appears to satisfy an exclusion restriction for models that use randomized award offers to identify causal effects. We find little support for other channels through which awards might affect completion. We also find that aid accompanied by academic support services (delivered through a program called Learning Communities) appears to generate no more degrees than do financial awards alone. Our results comparing recipients of academic support services with other award recipients should be seen as preliminary, however, since this relies on data for a single cohort.[3]

We conclude with an economic analysis of program costs for STBF applicants targeting four-year schools. This analysis highlights the gap between the private and social costs of marginal degrees. On average, scholarship awards to students targeting bachelor's degrees cost the funder $\$34.3K$, while raising direct costs of attendance (tuition plus books and supplies) by only $\$5.6K$. Viewed through this lens, most funder spending is a transfer. At the same time, the estimated lifetime earnings gains generated by scholarship awards appear likely to exceed the sum of incremental educational costs and foregone earnings for each of the subgroups examined here (defined by race, gender, academic preparation, and Pell eligibility). The comparison of expected gains with funder

[3]Larger samples, expected to be available in years to come, should generate more precise estimates of the causal impact of Learning Community services.

costs is more mixed, but gains are large enough to outweigh costs for award recipients whose degree attainment is strongly affected by scholarship awards. This includes the group of Pell-eligible applicants, nonwhite and urban applicants, applicants who have weaker academic preparation, and those without college-educated parents. From a funder's point of view, aid targeting increases program efficiency markedly.

2 Background

Our study builds on decades of empirical work examining causal effects of government-provided post-secondary financial aid. Since the pioneering investigation by Fuller, Manski and Wise (1983), economists have explored the hypothesis that post-secondary aid is largely inframarginal, leaving many recipients' college outcomes unchanged. The question of whether aid really boosts schooling is challenging because aid and educational attainment are correlated for reasons unrelated to the impact of aid itself. The risk of selection bias motivates sophisticated econometric identification strategies that exploit administrative or rule-based variation, such as income cutoffs and program timing. Marx and Turner (2018), for example, use discontinuities in the Pell Grant formula to evaluate aid effects on City University of New York (CUNY) students. Regression discontinuity (RD) estimates suggest Pell aid reduces CUNY students' borrowing without affecting their college enrollment. Another RD study, Cohodes and Goodman (2014), finds that a Massachusetts award program known as the Adams Scholarship reduces college completion by diverting recipients away from higher-quality private options. Other work, reviewed in Dynarski and Scott-Clayton (2008) and Deming and Dynarski (2010) yields a wide range of estimated aid effects.

Programs like the pathbreaking Georgia HOPE scholarship, the Massachusetts Adams Scholarship, and similar schemes in many other states, are of special interest to middle class and lower-income students who favor relatively inexpensive public colleges and universities. Dynarski (2004) reviews econometric studies of state merit aid programs modeled on Georgia HOPE. Most of this research exploits state-by-cohort variation in access to government aid. Programs that have since emulated the original HOPE model appear to have large effects on college attendance, though HOPE specifically seems to be among the most effective.

Our study is closely related to the Anderson et al. (2019) randomized evaluation of privately-funded grant aid for low-income public college students in Wisconsin allocated through a program known as the Wisconsin Scholars Grant (WSG). The WSG offered \$3,500 per year to Pell-eligible Wisconsin residents enrolled as full-time freshmen at four-year schools and up to \$1,800 per year to Pell-eligible two-year students. WSG awards seem to have engendered modest gains in sophomore enrollment for four-year students, with no evidence of award-induced enrollment effects among two-year students. Longer-term results suggest the WSG did not change degree completion. The WSG research design benefits from random assignment, but it bears emphasizing that STBF awards are more than twice as large as the Wisconsin Scholars Grant. Most critically, STBF awards target college-considering high school students, while WSG awards are made to already-enrolled first-year college students. This difference in timing features in our explanation of STBF-induced completion gains: we argue that these gains are driven by applicants who aspire to attend four-year programs but would not do so without aid.

2.1 The STBF Scholarship Program

STBF is the largest private provider of post-secondary grant aid in Nebraska, and almost certainly one of the largest in the country. STBF has been funding Nebraskan college students since 1965, and now supports nearly 4,000 students each year. More than half of Pell-eligible Nebraska seniors who apply for federal aid also apply for an STBF scholarship.[4]

Nebraska-resident high school seniors and Nebraska high school graduates who have not yet attended college are eligible for STBF awards. STBF financial support is awarded in view of financial need as summarized by the FAFSA expected family contribution (EFC), as well as on the basis of merit. EFC cutoffs for STBF awards were \$15,000 in 2012 and \$10,000 thereafter. For comparison, the 2013 Pell threshold was \$5,081. STBF applications are due February 1 of the calendar year when students aim to enroll (applicants may submit FAFSAs later), and scholarship decisions are announced in mid-April. Applicants are asked to identify a first-choice target school in the event they are funded (such as the University of Nebraska at Omaha, Chadron State College, or Mid-Plains Community College.) However, if awarded a scholarship, students can use it at any Nebraska public college.

[4] Authors' calculations from data obtained by request from the Federal Student Aid office.

STBF aid can be applied toward any federally-recognized cost of attendance (COA) at any public two-year or four-year college in Nebraska. Conditional on good academic standing (award recipients are expected to maintain at least a 2.0 GPA), STBF awards for four-year students are renewable for up to five years and awards for two-year students are renewable for up to three years. Award amounts are campus-specific, and calibrated to the relevant cost of tuition and fees plus a $500 book allotment. For example, 2013 awards provided $8,500 per academic year for full-time students at the University of Nebraska's Lincoln campus, where tuition and fees amounted to $8,060.

STBF aid has much in common with major public programs. Like the federal government's Pell program, STBF awards are based in part on financial need. Like many state aid programs, STBF considers a variety of applicant features including financial need, indicators of college readiness, and information about individual experience found in essays and letters of recommendation. Readiness criteria for STBF funding is based on high school GPA (recipients must have a high school GPA above 2.5). STBF awards are more generous than Pell grants and available to many applicants with an EFC above the Pell cutoff. On the other hand, some state programs approach STBF levels of generosity. (Deming and Dynarski 2010 compare award levels and treatment effects for a wide array of post-secondary support programs.) Generous state benchmarks include the CalGrant program examined by Kane (2003) and Bettinger et al. (2019), and the Texas Longhorn Opportunity Scholarship and Century Scholars programs evaluated by Andrews, Imberman and Lovenheim (2020). Combined with Pell, the Texas programs cover all tuition and fees at The University of Texas and Texas A&M. Like STBF awards, the Texas programs target low-income college-bound high school students and provide a range of academic support services to recipients who enroll at a covered campus.

Many recipients of STBF awards (known as Buffett Scholars) attend the University of Nebraska, known locally as "NU." Scholarship winners who attend one of NU's three main campuses— Lincoln (UNL), Omaha (UNO), or Kearney (UNK)—are required to participate in STBF-funded Learning Community (LC) programs during their first and second years of college.[5] These programs, detailed in Kezar and Kitchen (2020), incorporate a mix of college classes for STBF-funded students, social

[5]STBF introduced Learning Communities in 2008. From 2008 to 2013, all awardees participated in Learning Communities. After 2013, some scholarship recipients did not have to participate in LC programming. More information on these scholars follows.

activities, peer mentoring, and academic advising. Many LC participants at UNK and UNL live in dedicated dorm space.[6]

2.2 Research Design and Sample Construction

Among scholarship applicants aiming to enroll in the fall of 2012 through the fall of 2016, a subset of STBF awards were allocated by random assignment. Applicants in these experimental cohorts were first scored according to college-readiness, need criteria, and other factors important to the Foundation. The highest-scoring applicants (roughly 15 percent of the applicant pool) were guaranteed awards, while the lowest-scoring applicants (roughly 10 percent) were removed from consideration. The rest were subject to random assignment, with award rates determined by a variety of constraints on award counts at the target schools in each cohort. Because award rates differ, our regression estimates discussed below control for a full set of target-school by application-year dummies to reflect differing award rates. We refer to these controls as "strata dummies."

In the 2013–16 cohorts, treated applicants targeting NU campuses received one of two types of scholarships. The first, described to recipients as "Susan T. Buffett Scholarships" combined financial aid with an obligation to participate in LCs. The second, "College Opportunity Scholarships" (COS), consisted of aid only. This was designed to reveal any incremental treatment effects due to LC participation. In practice, awards with and without an LC component generate similar effects on college enrollment and degree completion. Our ability to distinguish effects of the two types of awards is limited, however, by the size of the COS treatment sample. Most of the analysis below therefore pools the two treatment groups.

The five cohorts involved in the randomized study include 3,699 treated applicants (applicants offered aid) and 4,491 controls. Of these, 6,845 indicated a four-year college as their target school were they to be funded; the rest indicated that they would prefer a two-year school. A breakdown of the number of applicants in the treatment and control groups by application year and target campus appears in Appendix Table A1. Of the 6,845 applicants targeting a four-year campus, 2,197 were offered STBF scholarships and 862 were offered COS awards (where only STBF awards include mandated LC participation for NU students). Of the 1,345 applicants targeting two-year schools,

[6]Impact evaluations of LC programs and LC-type services include Bloom and Sommo (2015), Angrist, Lang and Oreopoulos (2009), Weiss et al. (2015) and Bettinger and Baker (2014).

640 were offered scholarships. The discussion below distinguishes effects by target school program length, referring to applicants targeting NU and other four-year colleges as in the "four-year strata," and those targeting community colleges as in the "two-year strata."

2.3 Data and Descriptive Statistics

Data for this project come from the STBF online application, linked with administrative records from Nebraska's public colleges and from the National Student Clearinghouse (NSC), which covers most American post-secondary schools. Scholarship application records cover a rich set of baseline characteristics, including high school transcripts, ACT scores, and demographic and financial information from the FAFSA.[7] Over 90 percent of STBF applicants who ultimately enrolled in college attended a Nebraska public post-secondary school. These colleges and universities provided information on their students' enrollment, aid packages, and academic outcomes. To capture enrollment at private and out-of-state colleges, we supplemented school-provided data on post-secondary outcomes with information from the NSC. Appendix A provides additional information about data sources and data processing.

The first two columns of Table 1 compare eligible scholarship applicants with a statewide sample of high school seniors.[8] STBF applicants are from households with an average income equal only to about half the average for the broader population of Nebraska high school seniors. Compared to the average Nebraska high school senior, STBF applicants are disproportionately more likely to be female and less likely to have a parent who attended college. ACT scores among STBF applicants are similar to those of other Nebraska ACT test-takers, though applicants are more likely to have taken the ACT.

Consistent with the criteria used to evaluate applications, STBF's top-scoring applicants (guaranteed awards) have academic credentials well above the smaller group of applicants that did not qualify for random assignment. Columns 3 and 4 in Table 1 compare the top- and lowest-scoring applicants. Statistics for the experimental sample (the group subject to random assignment, described in column 5) show that applicants guaranteed STBF awards without random assignment

[7]Data on the race of 2012 and 2013 applicants comes from the state department of motor vehicles.

[8]Information on Nebraska public high school students was obtained from the Nebraska Department of Education online database, Surveillance, Epidemiology, and End Realties Program (SEER), and ACT National Reports (ACT 2012).

had lower family incomes and less-educated parents than applicants in the experimental group. This group also includes a higher proportion of Hispanic applicants. At the other end of the distribution, applicants disqualified before random assignment have lower high school grades and ACT scores than those subject to random assignment.

Finally, the last column of Table 1, which reports strata-adjusted differences in treatment and control characteristics, shows random assignment balanced the characteristics of treatment and control students. Appendix Table A2 reports similar balance statistics within target-school strata.

3 Gauging Award Impact

STBF paid $8,200 on average towards the first year of study for treated students targeting a four-year program. Panel A of Figure 1 shows that these awards boosted applicants' first-year financial aid packages from $13,300 to $17,500. Importantly, however, Panel B shows that while a dollar awarded raised total aid by only 52 cents, the gap between funder cost and amount received is due almost entirely to a reduction in loans. In fact, for every dollar awarded, grant aid rose 96 cents, with concomitant declines of 33 cents in loans and 5 cents in earnings through work-study programs. Appendix Figure A1 reports award effects on aid for applicants in two-year strata. Consistent with the much lower cost of two-year programs, Figure A1 shows average first-year award amounts of around $3,900. Here too, STBF awards increased grant aid substantially, in this case by one extra dollar for each dollar awarded.[9]

3.1 Effects on Enrollment and Degrees

The reduced-form analysis discussed in this section ignores considerations of initial award take-up. As 93 percent of applicants who receive an award accept it, this is innocuous. The more structured analysis outlined in the next section uses randomized award offers to construct two-stage least squares (2SLS) estimates of the effect of mediating post-secondary choices, like the type of college attended in the first year enrolled, on degree completion.

[9]Award effects on loans in the two-year strata are small because two-year students borrow relatively little.

Reduced-form treatment effects on post-secondary outcomes, Y_i, are regression estimates of coefficient ρ in the equation

$$Y_i = X_i'\delta + \rho A_i + \varepsilon_i, \tag{1}$$

where A_i indicates a scholarship was offered to applicant i. The covariate vector X_i includes saturated controls for application year and target institution, the strata variables that determine experimental award rates. Equation (1) was estimated using the 8,190 randomized applicants who applied between 2012–2016.

All but 4 percent of control-group applicants in four-year strata enrolled in college in the fall semester following their award application. Even so, as can be seen at the top of column 2 in Table 2, STBF awards boosted any-college enrollment rates among four-year applicants by a statistically significant 2.6 percentage points. Moreover, while award offers had only modest effects on any-college enrollment in the four-year strata, they appear to have increased enrollment in four-year programs by almost 11 points (on a base of 83 percent). Much of this gain is attributable to a 6.7 point decline in enrollment at two-year schools.

Like many state-funded financial aid schemes, the STBF program is meant to encourage in-state public college enrollment. The estimates in panel B of Table 2 show that STBF awards increased Nebraska public college enrollment among four-year applicants by almost 7 points, a gain driven by an even larger effect on NU enrollment. Paralleling the award-induced decline in any two-year enrollment, awards induced a marked decline in Nebraska community college enrollment. The estimates in Panel B also show a modest award-induced drop in out-of-state and private college enrollment.[10]

Columns 3 and 4 in Table 2 report estimates of the impact of regular awards (with LCs) and COS awards (without LCs) for applicants targeting an NU campus in the 2013-2016 cohorts. (Only students in these cohorts were eligible for COS awards.) Estimates of the regular award's impact is similar in this sample (column 3) and the full sample of four-year applicants (column 2). Within this sample, our estimates of the impacts of COS and regular awards are similar.

[10]Most STBF applicants who enrolled outside of Nebraska's public colleges and universities attended private schools in the Midwest. The top five schools outside Nebraska's public system were Nebraska Wesleyan University, Creighton University, Hastings College, Concordia University, and Midland University, all religiously-affiliated private institutions in Nebraska.

The initial enrollment gains generated by award offers in four-year strata led to a persistent increase in college enrollment. This is apparent in Figure 2, which plots treatment and control enrollment rates each semester after random assignment. The sample used to compute each point omits applicants who had completed a college degree by the time the enrollment outcome was recorded. Conditional on not having earned a degree, college enrollment in the treated group is sharply higher than college enrollment in the control group 2-5 years after random assignment. The figure therefore suggests that awards reduced college dropout rates (by keeping students in school early on) while also lengthening time to completion for some.

STBF award offers boosted college enrollment rates more for applicants in two-year strata than for applicants in four-year strata. In particular, the estimate at the top of column 6 in Table 2 shows a gain of 5.8 points in any-college enrollment for the two-year group (compared with a control mean of 90 percent, reported in column 5). Four-year enrollment gains are much smaller, however, for applicants in two-year strata: awards increase the probability a two-year targeting applicant enrolls in a four-year program by only 3.8 points. The estimates in panel B also show awards generated a marked gain in Nebraska public college enrollment for applicants in two-year strata, due mostly to a shift towards NU. Perhaps surprisingly, increased enrollment at NU appears to be mostly a net gain in college enrollment rather than a move away from two-year schools.

Our working paper presents additional estimates of award effects on college enrollment and persistence (Angrist et al. 2016).

Degree Completion

STBF awards boosted six-year BA completion rates by 8.4 percentage points for applicants in four-year strata, a substantial gain relative to the control mean of 63 percent. Estimated degree completion effects, currently available for the 2012-13 cohorts, appear in column 2 of Table 3. Even with data on only two cohorts, the overall estimated completion effect is reasonably precise, with a standard error of 0.02. A comparison of columns 2 and 3 shows that estimated regular award effects are similar when computed for all four-year targeters and 2013 applicants targeting NU. The estimated COS effect (column 4) is also close to the regular-award effect column 3) for this sample, though the COS estimates are somewhat less precise.

The increase in BAs is partly accounted for by a shift from two-year to four-year programs. STBF awards reduced associate degree completion by 3 points for applicants in four-year strata, with similar drops seen for the 2013-only NU sample and among COS award winners. Most of the 8.4 point gain in BA completion, however, is due to a 5.8 point decline in the likelihood that applicants earn no degree.[11]

As can be seen in column 6 of Table 3, awards do not appear to have increased associate degrees among applicants in two-year strata. Estimates in this column show a modest positive impact on BAs in two-year strata, but this estimate is not significantly different from zero. It seems especially noteworthy that awards made to applicants in two-year strata, who indicated a desire to attend two-year programs, have generated no discernible rise in two-year degree completion.

Figure 3 plots award effects on BA completion rates in years four through six, estimated separately by target campus for applicants in four-year strata. As suggested by Figure 2, STBF awards appear to have increased time to completion for some. This delay is visible in statistically significant declines in completion rates four years out for applicants targeting UNL and UNK of roughly 5 points. However, completion rates rise five years after random assignment. Award offers boost completion rates most clearly for applicants targeting UNO, by 8 points five years out and a remarkable 15 points six years out (both statistically significant). Estimated effects for applicants targeting other NU campuses are much smaller and close to the margin of statistical significance. Estimated five- and six-year completion effects for applicants targeting state colleges are positive, but considerably less precise than the corresponding estimates for applicants targeting NU.

The large degree gains seen for UNO applicants play a leading role in our account of the mechanism by which awards increase completion. UNO serves a mostly low-income, disproportionately nonwhite population. In comparison to applicants targeting other campuses, UNO-targeting award winners are less likely to enroll in a four-year college in the absence of STBF support. It's also worth noting that a year-by-year analysis of treatment effects in four-year strata shows similar degree gains for award winners with and without mandatory participation in LCs. This can be seen in Appendix Figure A2, which plots the two types of award effects estimated four to six years after

[11] Degree outcomes in Table 3 are not mutually exclusive.

random assignment. The analysis below therefore pools the LC and non-LC treatment groups in the four-year strata analyses.[12]

3.2 Degree Effects by Subgroup

Consistent with large award-induced degree gains for applicants targeting UNO, award effects are especially impressive for Omaha residents. This is documented at the top of Figure 4, which shows a 16 point effect on Omaha residents by year six, with only a (marginally significant) 5 point gain for other four-year strata applicants. The rest of the figure contrasts award effects in other demographic breakdowns of interest. In particular, we see degree gains of 12 points for treated nonwhite applicants, with a corresponding gain of only seven points for whites. This aligns with large effects for Omaha residents and applicants targeting UNO since nonwhite Nebraskans are concentrated in Omaha.[13] At the same time, Figure 4 shows little difference in impact by gender. Finally, the figure shows award effects that are larger for Pell-eligible applicants than for applicants with family incomes above the Pell threshold. This too aligns with differences in impact by race and Omaha residence since Pell-eligible applicants are over-represented in Omaha.

Figure 5 reports completion rates and estimated degree gains in subgroups defined by variables that predict college readiness. Here, we see larger gains for the less-prepared. Among applicants with ACT scores below the Nebraska median, awards appear to boost six-year completion rates by 14 points, with a gain of only 5 points in the complementary subgroup. This difference is made even more impressive by the low completion rate in the low-ACT control group (43%). Estimates by high-school GPA show a similar pattern. Figure 5 also shows an estimated effect for first-generation applicants that's twice as large as the estimate for applicants from more-educated families. The estimated award effect among four-year applicants who indicated they considered attending a two-year program is slightly higher than the estimate for the complementary subgroup.

[12]These estimates may change as degree data are added to the COS-eligible sample. Currently, differences in COS award effects by target campus are not statistically significant.

[13]Nearly 60 percent of Omaha-resident applicants are nonwhite. Other statistics for Omaha residents appear in Appendix Table A3.

4 Explaining Award Effects

The widely-differing subgroup effects plotted in Figures 3 through 5 are explained here by a causal mediation story that hinges on the type of campus at which applicants first enroll. Specifically, we argue that an award-induced shift towards early and strong engagement with a four-year college is the primary channel by which STBF aid generates additional bachelor's degrees. Variation in the strength of award-induced shifts toward four-year programs by applicants' target campus, demographic group, and college-readiness provides a coherent account of reduced form treatment effects across all of these groups.

4.1 College Targets and Destinies

Most award recipients in four-year strata started their college careers on a four-year campus. But many applicants not selected for an award also embarked on a four-year program, especially those with a four-year target. How did awards change the likelihood of four-year college enrollment? We describe the nature and extent of award-induced changes in initial college enrollment using the notion of potential enrollment.

Let categorical variable W_i contain the name of the first college at which applicant i enrolls and define potential school enrollment variables W_{0i} and W_{1i} indexed by award offers, A_i. Potential enrollment variable W_{1i} names the school where applicant i would enroll when offered an award, while W_{0i} names the school where i enrolls otherwise. Observed enrollment can be written as

$$W_i = W_{0i}(1 - A_i) + W_{1i}A_i. \tag{2}$$

Similarly, it's useful to define an indicator of potential target-school attendance,

$$T_{ki} = 1\{W_{ki} = \tau_i\};\ k = 0, 1,$$

where τ_i is the name of applicant i's target campus. Potential target attendance variable T_{1i} indicates applicants who enroll at their target school when offered an award, while T_{0i} indicates those enrolling in the target without an STBF award. Observed target enrollment, T_i, is determined by potential target enrollment following a equation similar to (2).

Invoking a monotonicity condition analogous to that introduced by Imbens and Angrist (1994), we assume STBF awards never inhibit target college enrollment. The effects of an award on T_i for applicants with $X_i = x$ then determine the target compliance share for this group. Formally, we have

$$E[T_i|A_i = 1, X_i = x] - E[T_i|A_i = 0, X_i = x] = E[T_{1i} - T_{0i}|X_i = x] = P[T_{1i} > T_{0i}|X_i = x], \quad (3)$$

as long as the conditioning vector X_i includes controls for random assignment strata. The first equality in equation (3) is a consequence of the conditional random assignment of A_i, while the second reflects monotonicity, which means that $T_{1i} \geq T_{0i}$. In a model with additive control for covariates, target compliance is identified by the coefficient on A_i in a regression of T_i on A_i and X_i.

The effects of STBF awards on T_i mostly mirror the award effects on degrees. We document this similarity in Panel A of Figure 6, which plots the effects of A_i on target enrollment by strata and subgroup. Dots on the bars in Figure 6 mark group-specific award effects for reference. We see, for example, that among four-year applicants targeting UNO, target compliance is almost double target compliance for applicants in other four-year strata. Likewise, target compliance is higher for nonwhite students and Omaha residents. On the other hand, compliance is similar for men and women. With one exception (the split by Pell-eligibility), target compliance differentials are consistent with the direction of differences in group-specific award effects.

Award effects on target compliance by measures of college readiness also parallel the differences in degree gains seen across college-readiness subgroups. Figure 5 shows especially large degree gains for applicants with below-median ACT scores and below-median high school GPAs. Differences in target compliance across these splits are also large, with higher target compliance in less-ready groups.

By definition, target compliers in the four-year strata enroll in a four-year program when $A_i = 1$. Even so, target compliance helps explain degree gains because, for many applicants in the four-year strata, non-target programs are unlikely to lead to a BA. We show this by grouping college choices into categories labeled by $c \in \{4, 2, 0\}$ for four-year, two-year, and unenrolled students, respectively. Let $1\{W_{0i} \in c\}$ indicate enrollment in college category c when a student does not have an STBF award. The conditional mean of this variable,

$$\omega_c = E[1\{W_{0i} \in c\}|T_{1i} > T_{0i}],$$

measures the rate at which target compliers enroll in different sorts of programs in the event they fail to receive an award. As in Abdulkadiroglu et al. (2017), we refer to ω_c as describing the distribution of counterfactual destinies. We can estimate ω_c using 2SLS.[14]

Panel B of Figure 6 plots estimated destiny distributions for target compliers in four-year strata, separately by target campus and subgroup. A key finding here is the substantial heterogeneity across subgroups in the fraction of compliers who enroll in four-year programs without STBF aid. In the breakdown by target campus, for example, only those applicants targeting UNO are very unlikely to find their way to a four-year program absent an STBF award. This fact, in combination with a relatively high target-campus compliance rate in the UNO group, contributes to the out-sized degree gains among applicants targeting UNO. A similar pattern is visible in other conditional destiny contrasts: applicants in demographic and college-readiness subgroups where degree gains are most impressive, such as Omaha residents and applicants with low ACT scores, are especially unlikely to end up in a four-year program absent an STBF award.

4.2 Measuring Mediation

Figures 4–6 show remarkable alignment between patterns of degree gains, target compliance, and college enrollment destinies across strata and subgroups. This alignment suggests a parsimonious mediation hypothesis that focuses on early engagement with four-year programs. To make this hypothesis concrete, let f_{1i} denote the fraction of a full-time four-year course load an applicant completes in the school year immediately following random assignment.[15] Our mediation hypothesis leads to model in which awards boost f_{1i}, which in turn increases BA completion, Y_i. This model

[14] Abadie (2002) shows how to identify the marginal distributions of outcomes and complier characteristics in treated and untreated states under assumptions like those in Imbens and Angrist (1994). In this case, the destiny distribution is identified by an IV estimand that uses A_i to instrument $(1 - T_i)$, with outcome variable $(1 - T_i)1\{W_i \in c\}$:

$$\omega_c = \frac{E[(1 - T_i)1\{W_i \in c\}|A_i = 1] - E[(1 - T_i)1\{W_i \in c\}|A_i = 0]}{E[(1 - T_i)|A_i = 1] - E[(1 - T_i)|A_i = 0]},$$

computed separately for each c. The estimates reported in Figure (6) control for covariates and were therefore computed using 2SLS.

[15] Under the rules for award determination, a full load is defined as 12 credit units per semester and 24 credit units per year.

can be written:

$$Y_i = \beta_1' X_i + \mu_1 f_{1i} + \varepsilon_{1i} \tag{4}$$

$$f_{1i} = \pi_{10}' X_i + \pi_{11} A_i + \left(\pi_{12}' X_i\right) A_i + \eta_{1i}, \tag{5}$$

where ε_{1i} in equation (4) is the random part of potential degree completion in the absence of treatment, and μ_1 is the causal effect of interest. Equation (5) is the first stage for a 2SLS procedure that uses A_i to instrument f_{1i}. The first stage residual, denoted η_{1i} in equation (5), is uncorrelated with A_i by construction.

Equation (5) allows the first-stage effect of award offers on first-year four-year credits to vary with covariates. We can write the covariate-specific first stage as:

$$\pi(X_i) = \pi_{11} + \pi_{12}' X_i.$$

Importantly, the causal relationship of interest, modeled by (4), omits interactions between f_{1i} and X_i. The reduced form implied by (4) and (5) therefore satisfies

$$\rho(X_i) = E[f_{1i}|X_i, A_i = 1] - E[f_{1i}|X_i, A_i = 0] = \pi(X_i)\mu_1, \tag{6}$$

for each value of X_i. In other words, the IV assumptions motivating (4) and (5) imply that <u>all</u> heterogeneity in reduced-form aid effects by strata and subgroup is explained by differences in the extent to which offers change early four-year engagement, f_{1i}.

Figure 7 gauges this mediation hypothesis with a "visual instrumental variables" (VIV) picture of μ_1. This VIV figure plots estimated reduced-form effects for degree outcomes, $\hat{\rho}(X_i)$, against the corresponding first-stage estimates, $\hat{\pi}(X_i)$. The sample includes applicants in two-year and four-year strata, with a single cell for all applicants in the two-year group. The vector X_i includes dummies indicating four-year target campuses (UNO, UNL, UNK, and state colleges), and dummies for the demographic and college-readiness subgroups in Figures 4 and 5. Because both $\hat{\rho}(X_i)$ and $\hat{\pi}(X_i)$ vary freely with X_i, the slope of the line through these points is an IV estimate of μ_1 identified by instrumenting f_{1i} in equation (4) using both A_i and the set of interactions between X_i and A_i. The figure also plots the point determined by "pooled" first stage and reduced form estimates generated by an IV model without interactions.[16]

[16] The figure plots fitted values from a sample-size weighted regression of $\hat{\rho}(X_i)$ on $\hat{\pi}(X_i)$, omitting the pooled estimate since this point is implied by the cell-specific estimates. The sample in this case is the number of observations

A regression of $\hat{\rho}(X_i)$ on $\hat{\pi}(X_i)$ fits remarkably well (see Panel A of Figure 7). The fitted line has a slope of 0.58 when estimated with no intercept (as implied by the proportionality restriction embodied in equation (6)). The first-stage estimate for female applicants in four-year strata suggests STBF offers boost f_{1i} by about 0.11. This, in turn, boosts BA completion by about 6.3 points, so the implied IV estimate for this group is 0.57, close to the slope of the line. Without conditioning on X_i, the just-identified IV estimate (using only award receipt as an instrument) is 0.59, with an estimated standard error of 0.14. We report these estimates at the top of column 2 in Table 4. The corresponding OLS estimate, that is, the slope from an un-instrumented regression of BA completion on f_{1i} controlling for X_i, is remarkably close to the IV estimate at 0.58. We report this estimate in the first column of Table 4.

Other panels in Figure 7 and Table 4 repeat the analysis of Panel A with different dependent variables. The VIV and 2SLS estimates in Panel B of these exhibits suggest f_{1i} boosts overall degree attainment by only around 0.37, a gain well below the estimated increase in BAs. As can be seen in Panel C, this discrepancy between increased BAs and overall degree gains reflects the fact that early engagement with four-year colleges decreases associate degrees.

The conventional over-identification statistic associated with 2SLS provides a formal test of the hypothesis that variation in $\rho(X_i)$ is explained by variation in $\pi(X_i)$. This test statistic is essentially a scaled version of the R^2 for the lines plotted in Figure 7 (see, e.g., Section 2.2.2 of Angrist and Pischke 2009). Test results, along with the associated 2SLS estimates and first-stage F-statistics, appear in columns 3–5 of Table 4 for alternative specifications of X_i. The large p-values associated with the over-identification test statistics suggest that any deviation between sample moments and the proportionality hypothesis expressed by equation (6) can be attributed to sampling variance.

Shifting College Credits

Awards move some students on the extensive margin; for these students, four-year college is a binary, yes-no decision. For others, however, awards may affect the number of credits earned. How much does the intensity of four-year college engagement contribute to the causal mediation

at each value of X_i; within X_i cells, instrument-specific cell means are unweighted. Conventional 2SLS implicitly weights both covariate- and instrument-specific conditional means by the corresponding cell size (see, e.g., Angrist and Pischke 2009). The estimates plotted in Figure 7 and reported in Table 4 are from models that include the vector X_i as controls.

story suggested by Figure 7 and Table 4? Figure 8 gauges this effect in two ways. Panel A plots the histograms of four-year credits earned in the first post-treatment year, separately for treatment and control applicants in four-year strata. The figure documents a large decline in the likelihood of having earned zero four-year credits, from around 12 percentage points in the control group to around 4 in the treated group, a statistically significant decline. The histograms also show clear increases in the probably of earning 24–28 four-year credits. This finding is significant because 24 credits marks a full-time load.

Panel B of Figure 8 provides another view of the award-induced credit shift. This panel plots the scaled treatment-control difference in the probability an applicant earns at least s credits, for each value of $s \in [1, 40]$. This plot is motivated by Angrist and Imbens (1995), which shows that in causal effect models of an ordered treatment, an IV estimator using a dummy instrument identifies a weighted average of single-unit causal effects (called average causal response, or ACR). The ACR averages the one-unit average causal effects of increasing credits from $s - 1$ to s, for each s. Single-unit effects are specific to applicants who were induced by awards to move from fewer than s to at least s credits. Under assumptions detailed in Angrist and Imbens (1995), the weights are the control-minus-treatment difference in the cumulative distribution function of credits earned in each group, divided by the corresponding first-stage (the normalization factor). These weights can be interpreted as the probability that an award causes an applicant to go from fewer than s to at least s credits earned.

If awards move some applicants from zero credits earned to 24 or more credits earned, with no one landing on any intermediate value, the weighting function should be flat for $s \in [1, 24]$. Panel B of Figure 8 supports this scenario, showing a reasonably flat weighting function from $s = 1$ through $s = 24$, with a slight rise between 12 and 24. This pattern suggests that most applicants for whom awards impact four-year engagement move from having no credits to at least half-time study. A few, however, move from low-intensity study to more intense but still part-time study. The fact that the weighting function declines steeply after 24 suggests awards do little to move students to more than full-time engagement.

Dynamic Exclusion

Figure 7 and Table 4 support the hypothesis that early four-year college engagement is a key channel through which STBF awards increase BA completion. But this finding raises the question of why we should focus on initial engagement and not, say, sophomore or junior-year measures of credits earned. Is engagement in the first year of college the key step on the path to BA completion? Defining f_{ti} as the fraction of a full credit load earned in year t, it seems reasonable to imagine that awards boost f_{ti} for $t > 1$ as well as boosting f_{1i}. These gains, in turn, may also contribute to degree completion.

In assessing alternative hypotheses, we note that credit completion is serially correlated: credits earned in one year predict credits earned later. In particular, award-induced gains in f_{1i} are likely to be visible in subsequent f_{ti}. In practice, award-induced changes in downstream f_{ti}, as well as the consequences of these changes for BA completion, can be explained entirely by award effects on f_{1i}. This finding leads to a dynamic exclusion hypothesis that strengthens the case for f_{1i} as the key mediator.

The first row of Table 5 shows that increases in f_{ti} boost degrees. Specifically, this row reports 2SLS estimates of coefficient μ_{ti} in a causal model for the effect of f_{ti} on degree completion that can be written as

$$Y_i = \beta_t' X_i + \mu_t f_{ti} + \varepsilon_{ti};\ t = 2, 3, 4. \tag{7}$$

The resulting estimates of μ_t are around 0.6 (the corresponding OLS estimate, reported in column 1, is 0.58). The instruments here are an award dummy, A_i, interacted with the same strata and covariates (i.e., elements of X_i) used to compute the estimates in Table 4. In this case, however, the sample is limited to applicants in four-year strata since degree gains are concentrated in this group. Table 5 also reports the first-stage F-statistic for these over-identified models. Some of the F-statistics are low enough to be worrying, but the associated IV estimates vary little as we add interactions to the instrument list.[17] The corresponding over-identification test statistics, reported at the bottom of Panel A in Table 5, provide little evidence of instrument-error correlation. Thus,

[17] LIML estimates of μ_t (not shown) are virtually indistinguishable from the corresponding 2SLS estimates.

like equation (4), equation (7) seems consistent with the hypothesis of a single causal channel through which awards generate degrees.

Large values of μ_2, μ_3, and μ_4 in equation (7) can be reconciled with a model attributing all award effects to f_{1i} if award effects on f_{ti} are themselves due to award effects on f_{1i}. The following model of engagement dynamics formalizes this idea:

$$f_{ti} = \alpha_t' X_i + \psi_t f_{1i} + \xi_{ti}, \tag{8}$$

where ψ_t is the causal effect of f_{1i} on f_{ti} and ξ_{ti} is a residual assumed to be uncorrelated with A_i. Panel B in Table 5 reports IV estimates of ψ_t in equation (8), computed using the same instruments used to estimate μ_t in Panel A. 2SLS estimates of ψ_2 are consistently close to one, while corresponding estimates of ψ_3 and ψ_4 are smaller. Across the board, however, gains in f_{1i} are seen to yield large gains in four-year credits down the road. Moreover, the over-identification test statistics associated with 2SLS estimates of equation (8) are consistent with the claim that STBF awards affect four-year credits earned in later years solely by increasing f_{1i}.

The exclusion restrictions that identify equations (7) and (8) imply an illuminating cross-equation restriction. In particular, using (8) to substitute for f_{ti} in (7) shows that the coefficient on f_{1i} in equation (4) satisfies:

$$\mu_1 = \psi_t \mu_t, \tag{9}$$

while the residual in this equation is formed as $\varepsilon_{1i} = \varepsilon_{ti} + \mu_t \xi_{ti}$. Therefore, we can derive the exclusion restriction described by (6) from exclusion restrictions imposed on equations (8) and (7).

Is (9) worth testing? It's easy to show that, with a single instrument and a common sample, IV estimates of μ_1 must equal the product of IV estimates ψ_t and μ_t. In an over-identified model, however, testing (9) is the same as testing over-identification in (8).[18] The bottom of Table 5 compares 2SLS estimates of μ_1 computed using equation (4) with the product of the 2SLS estimates of μ_t and ψ_t in (7) and (8). These alternative estimates of μ_1 are remarkably close to each other.

[18] Note that as long as $\hat{\psi}_t$ is positive, the sample analog of (9) holds if and only if

$$\hat{f}^*_{ti} = \psi_t \hat{f}^*_{1i},$$

where hats denote first-stage fitted values and stars signify the partialing out of control vector X_i. Provided the matrix of instruments has full column rank, this is equivalent to the vector of sample restrictions evaluated by the over-identification test statistic associated with exclusion of offer dummies and interactions from (8).

Although this comparison does not add any statistical information, this finding suggests that the over-identifying restrictions at hand are acceptable not merely because the underlying IV estimates are noisy, but rather because they are close to those implied by the dynamic exclusion hypothesis.

5 Comparing Costs and Benefits

By way of a provisional cost-benefit analysis, we compare predictions of the award-induced increase in lifetime earnings with measures of program cost (this analysis is provisional because we anticipate estimating earnings effects in future work). The funder's costs are easily measured and may affect program viability, but these are not economic costs since most scholarship spending is a transfer. Scholarships may increase overall educational spending, however, by increasing time spent in school and by moving students into more expensive programs. We therefore use the experimental framework to measure the incremental spending induced by awards, while also reporting per capita funder spending.

To determine the impact of award offers on funder spending, we put aid disbursements, D_i, on the left hand side of the reduced-form model for treatment effects, that is, equation (1). No aid is disbursed for control group applicants, so the effect of STBF offers on D_i captures average funder spending on treated applicants.

To quantify the extent of marginal educational spending, that is, spending induced by awards, we replace the cost variable D_i with a measure of the cost of college attendance. This variable, denoted COA_i, is proxied by the federally-determined cost of attendance as reported in the Institutional Characteristics File of the publicly-available Integrated Postsecondary Education Data System (IPEDS, U.S. Department of Education 2019). The imputed COA_i variable used here covers tuition, fees, and an allowance for books and supplies. A value of COA_i is computed for all ever-enrolled applicants, including those who attend private schools or non-Nebraska public schools.[19]

The statistics for D_i and COA_i reported in Panel A of Table 6 highlight the difference between STBF disbursements and marginal educational spending. As with the estimates of average funder

[19] This computation omits housing and transportation costs and uses the smaller of credit-based costs or full-time tuition. Cost data are missing for one applicant. Costs of books and supplies for eight percent of applicants are imputed using averages for two- and four-year schools.

cost, treatment values of average COA_i in this panel are obtained from a regression of imputed COA_i on strata and treatment dummies. Average COA_i is roughly $\$33,700$ among treated applicants in the four-year strata, close to average program disbursements in this group ($\$33,600$). On the other hand, while mean D_i is zero for controls, average control COA_i is around $\$28,000$, only modestly below average cost in the treated group.

To put these costs in perspective, Panel B reports funder spending and incremental educational spending (marginal COA) on the extra degrees attributable to STBF awards. For example, this calculation divides funder cost per treated applicant of $33,600 in four-year strata by the 0.084 new BAs created by the treatment, yielding a per-degree cost of $400,000. Funder costs range from a high of $738,000 for applicants targeting UNK to a low of $238,000 in the UNO stratum, where awards had the biggest impact. High funder costs reflect the fact that most spending is inframarginal, at least as far as degrees go. The second row of Panel B shows that marginal spending, that is, incremental COA for each degree created, is well below per-degree funder cost. Dividing the second row in the panel by the first shows marginal spending to be no more than 20 percent of funder spending. The level of per-degree marginal spending ranges from $49,000 in the UNO group to a little below $100,000 for applicants targeting UNL and UNK.

Finally, Panel C of Table 6 allocates award effects on COA_i to a component that reflects increased time in school and a component that reflects a shift towards more expensive programs. We refer to the latter as "cost-upgrading." To gauge the relative importance of these components, let COA_{1i} denote college costs incurred when applicant i is treated and let COA_{0i} denote costs incurred otherwise. Because $\{COA_{ji}; j = 0, 1\}$ is the product of years enrolled (denoted S_{ji}) and cost per year (denoted F_{ji}), we can write:

$$\begin{aligned} log(COA_{1i}) - log(COA_{0i}) &= log(S_{1i}F_{1i}) - log(S_{0i}F_{0i}) \\ &= \underbrace{log(S_{1i}) - log(S_{0i})}_{\text{extra years}} + \underbrace{log(F_{1i}) - log(F_{0i})}_{\text{extra cost per year}}. \end{aligned}$$

The first term on the second line of this expression captures incremental costs generated by more time in school, while the second captures cost upgrading, both measured in proportional terms. The average of each piece is obtained by putting observed time in college and per-semester spending, respectively, on the left-hand side of equation (1). Averages of the levels of cost components (S_{0i}, S_{1i}, F_{0i}, and F_{1i}) appear in Panel A of Table 6.[20]

As can be seen at the top of Panel C, awards increased COA_i by 23 log points. This estimate differs from the marginal share reported at the bottom of Panel B because the implicit base here is control average COA, that is, $E[COA_{0i}]$, rather than average funder cost for the treatment group. The pattern of proportional marginal spending across applicants' target strata again mostly parallels the magnitude of treatment effects on BA completion and years of schooling. In particular, marginal spending is highest for UNO applicants. The remaining entries in Panel C show that overall marginal spending is due to lengthened time in college and cost upgrading in approximately equal measure. Cost-upgrading therefore makes a substantial contribution to marginal spending. At 17 percent, the proportional cost increase from upgrading is largest for applicants targeting UNO, as we might expect given the relatively low probability applicants in this group would have enrolled in a four-year program absent treatment. Among applicants targeting UNK and state colleges, by contrast, estimated cost-upgrading effects are not significantly different from zero.

5.1 Projecting Lifetime Earnings Gains

The expected lifetime earnings impact of scholarship aid is forecast using a Mincerian wage equation fit to 2012-16 American Community Survey (ACS) data for employed Nebraska-born men aged 18-70 with at least a high school degree. The wage equation can be written:

$$\ln w_i = \beta_1 f(s_i) + \beta_2 e_i + \beta_3 e_i^2 + \beta_4 f(s_i) e_i + \beta_5 f(s_i) e_i^2 + \varepsilon_i, \qquad (10)$$

where w_i is real hourly earnings calculated from the ACS, s_i is years of education, and e_i is years of potential experience. Equation (10) includes a quadratic function of potential experience, an additive function of s_i, and interactions between the two. Hourly wages are converted to annual earnings assuming workers work 2000 hours per year. The predicted present value of lifetime earnings as a function of schooling and experience is obtained by summing the fitted values yielded by this model.[21]

[20] Per-semester spending is an average for each individual student, computed over the student's semesters enrolled. This analysis omits 15 applicants (4 treatment, 11 control) who never enrolled in college.

[21] The underlying regression estimates appear in Appendix Table A5. Details of this calculation can be found in Appendix Section A.

Predicted annual earnings are computed using two alternative choices of $f(s_i)$. The first uses the degree completion data reported in the ACS and the years of schooling values assigned to these by Jaeger and Page (1996). Potential experience is defined as $e_i \equiv \max\{\text{age}-\hat{s}_i - 6, 0\}$, where $\hat{s}_i$ is the Jaeger and Page (1996) imputed years. This specification assumes returns to schooling are linear, with no 'sheepskin' or degree effects. The second specification focuses on degrees, specifying $f(s_i)$ to be a pair of dummy variables indicating two-year or four-year degree attainment, with high school graduates and below as the omitted group.[22] The formula for potential experience, however, is unchanged. In this specification, each year of college reduces potential experience but increases predicted earnings only for those completing a degree.

Table 7 reports estimates of the PDV of expected lifetime earnings in treatment and control groups. Applying a discount rate of three percent, STBF awards are estimated to raise the PDV of lifetime earnings by $33,600 when computed using years of schooling for earnings prediction and by $29,200 when schooling returns reward degrees only. With a discount rate of five percent, the estimated gains fall to $13,200 when computed using the linear model and to $13,900 under the degrees specification. Perhaps surprisingly, with a low discount rate and linear returns to schooling, STBF awards are cost-effective in the sample as a whole in spite of the fact that the bulk of award spending is inframarginal. Positive returns reflect the fact that schooling is valuable: estimates of (10) imply that a BA raises the PDV of lifetime earnings by about $450,000. These estimates are roughly in line with those reported in Avery and Turner (2012).

5.2 Picturing Costs and Benefits

Figure 9 puts the cost-benefit pieces together for each of the subgroups considered in Section 4.[23] The cost-benefit comparisons in the figure take the form of intervals, with the top marker indicating funder costs and the bottom indicating marginal educational spending, that is, effects on COA_i. Predicted lifetime earnings gains are plotted for each group using the linear and degrees versions of the wage equation. As in Avery and Turner (2012), these are computed using a discount rate of three percent.

[22] The BA group includes those with higher degrees.

[23] Appendix Table A6 reports the estimates plotted in the figure.

For many groups, predicted earnings gains fall between funder costs and marginal COA_i, a finding that suggests STBF awards generate a positive social return while costing the funder more than award-induced earnings gains. Interestingly, however, the earnings gains predicted by the linear model exceed funder costs for nearly half of the subgroups considered. Groups meeting this test include Pell-eligible applicants, applicants with below median grades or ACT scores, nonwhite applicants, first-generation applicants, and Omaha residents. The cost-benefit comparison is less favorable when time in school has no intrinsic value. Assuming that schooling that does not lead to degrees has no effect on earnings leaves six groups above the funder-cost threshold.

Based as they are on a predictive model of lifetime earnings, these cost-benefit comparisons are provisional. In some respects, however, they're conservative, ignoring the fact that college degrees tend to boost hours worked as well as hourly wages (Murphy and Topel 2016). The calculations underlying Table 7 and Figure 9 also ignore any economic return to reductions in college debt, such as improved productivity at school or in work. Scholars have also suggested that the economic returns to education may be especially high for students whose school decisions are sensitive to financial constraints (see, e.g., Card 2001 and Zimmerman 2014).

6 Summary and Conclusions

Most college financial aid is motivated by a desire to increase educational attainment for students who would otherwise find themselves unable to complete a degree. It's therefore worth evaluating aid programs in light of this simple goal. The results of our randomized evaluation of an unusually generous aid program are both encouraging and cautionary. On one hand, STBF awards increase four-year degrees substantially. On the other, gains in degree completion are unevenly distributed. The bulk of award spending is a transfer flowing to applicants whose schooling behavior is unchanged by awards. Aid boosts degree completion most sharply for applicants who aspire to a BA, but are unlikely to embark on a four-year program in the absence of aid. Those who benefit most include groups of applicants seeking to enroll at UNO, Omaha residents, nonwhite applicants, and applicants with below-median grades and test scores.

We explain the pattern of degree effects with a parsimonious model that makes the main mediator of award impact a credit-based measure of initial engagement in a four-year college. Estimates of this model support the notion that awards induce degree completion in proportion to the extent that they spark and deepen early engagement with four-year college programs. This finding suggests there may be a large payoff to other, perhaps less costly, interventions that act to enhance early engagement (examples include Bulman 2015 and Carrell and Sacerdote 2017).

Most STBF spending on aid is a transfer, flowing to applicants likely to earn degrees even without an award. The flip side of high transfer cost is the fact that the marginal educational spending induced by STBF awards is low. For each subgroup considered here, the projected net earnings gains from scholarship-induced schooling outweighs the corresponding marginal cost. Moreover, although most award money is inframarginal, by one measure, the projected earnings gains for roughly half of the subgroups considered here exceeds the corresponding funder cost. Even so, our evidence indicates that greater front-loading and increased targeting of financial aid awards is likely to accomplish even more. Conversely, integrated aid—for example, universal publicly paid tuition—is likely to generate many fewer college degrees per dollar awarded.

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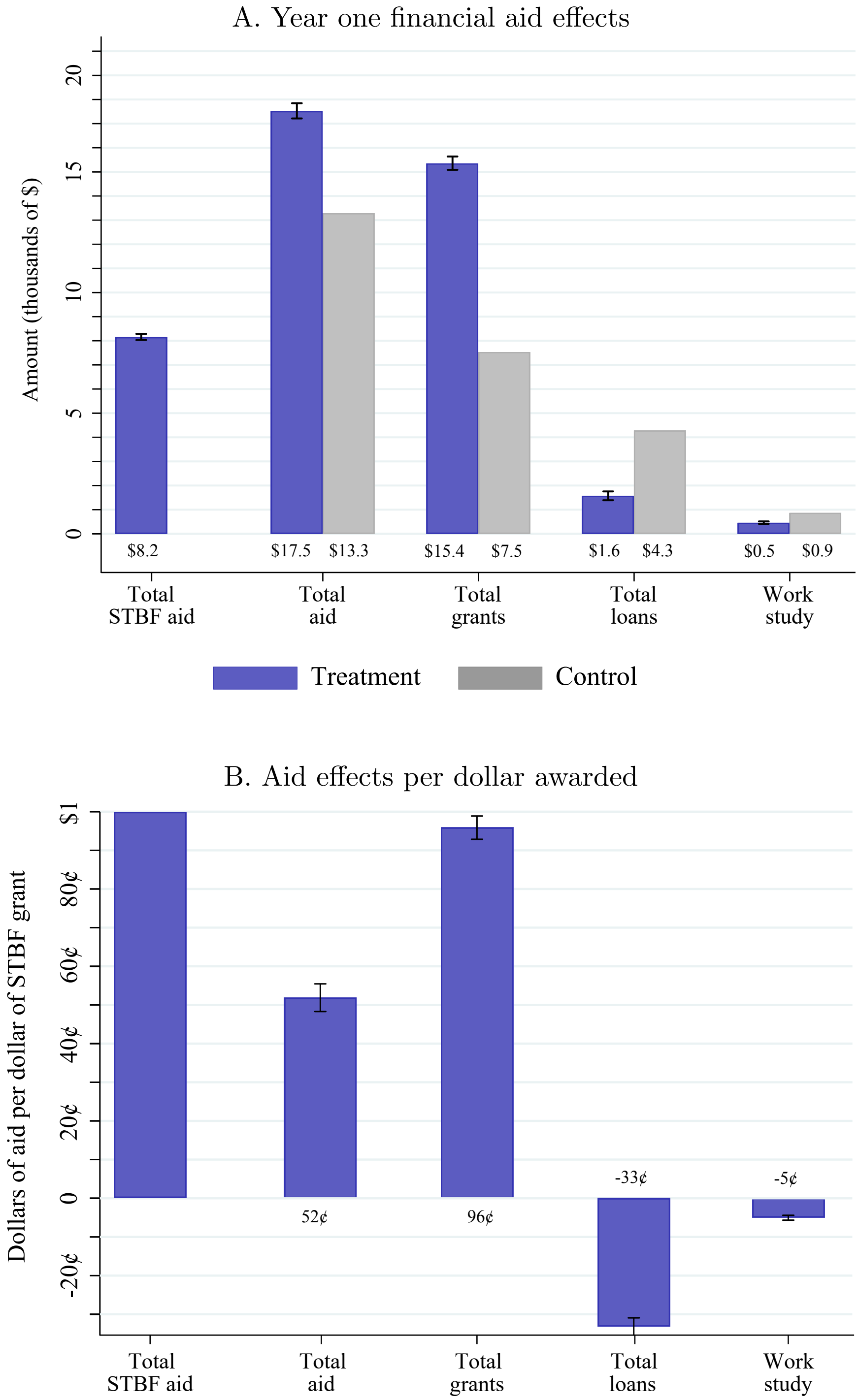


Figure 1 — Award effects on on post-secondary aid for applicants in four-year strata. *Notes:* This figure shows the effect of an STBF award offer on aid of various kinds in the year after scholarship application. The sample is restricted to students who targeted four-year colleges and enrolled at a Nebraska public institution. Whiskers mark 95 percent confidence intervals for the treatment effect of an award offer. The regressions used to estimate treatment effects control for strata dummies.

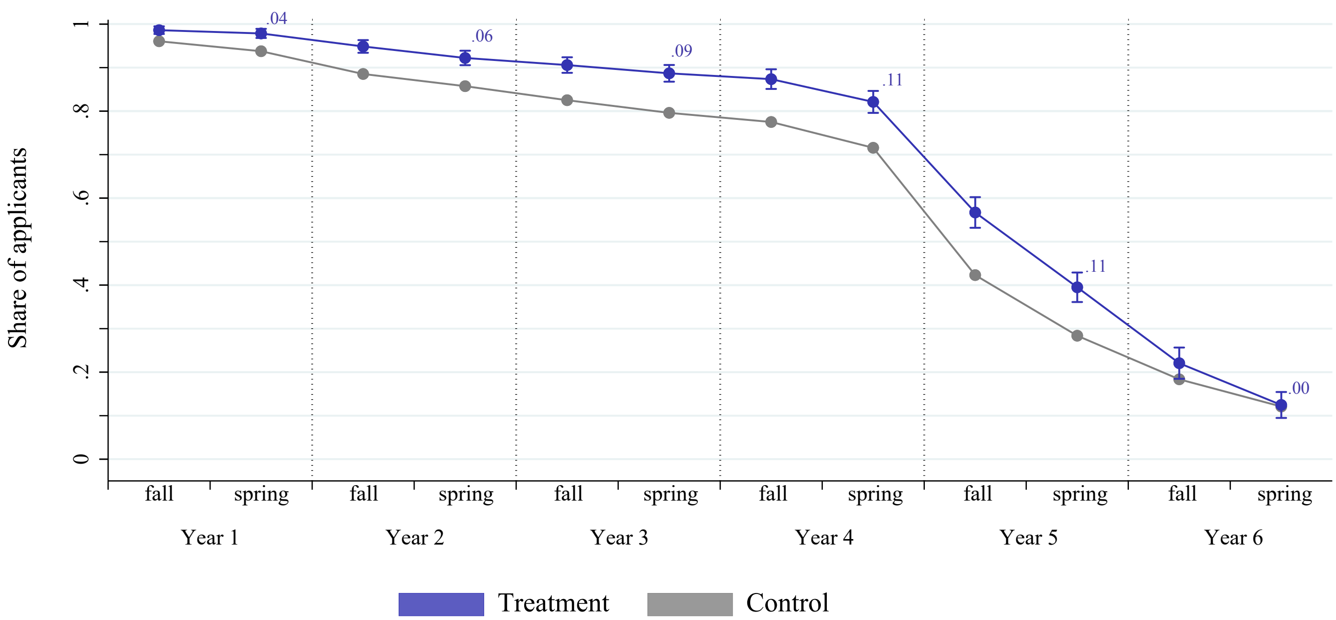


Figure 2 — Enrollment effects in the four-year strata. *Notes:* This figure plots the effect of an award on enrollment rates for students in the four year strata without a BA. Samples differ by year. Regressions control for strata dummies. Whiskers mark 95 percent confidence intervals.

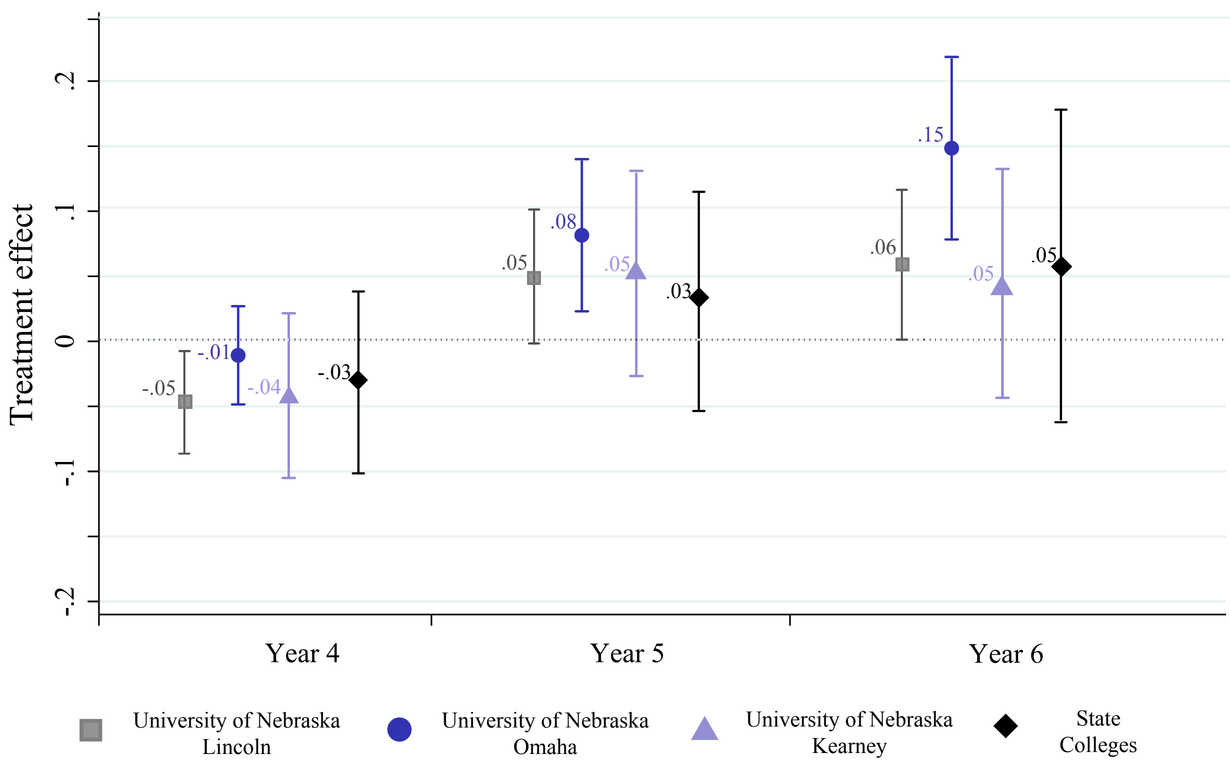


Figure 3 — BA effects by target campus. *Notes:* This figure plots the effect of an STBF award on degree completion for applicants targeting four-year campuses. Sample differs by year. Whiskers mark 95 percent confidence intervals.

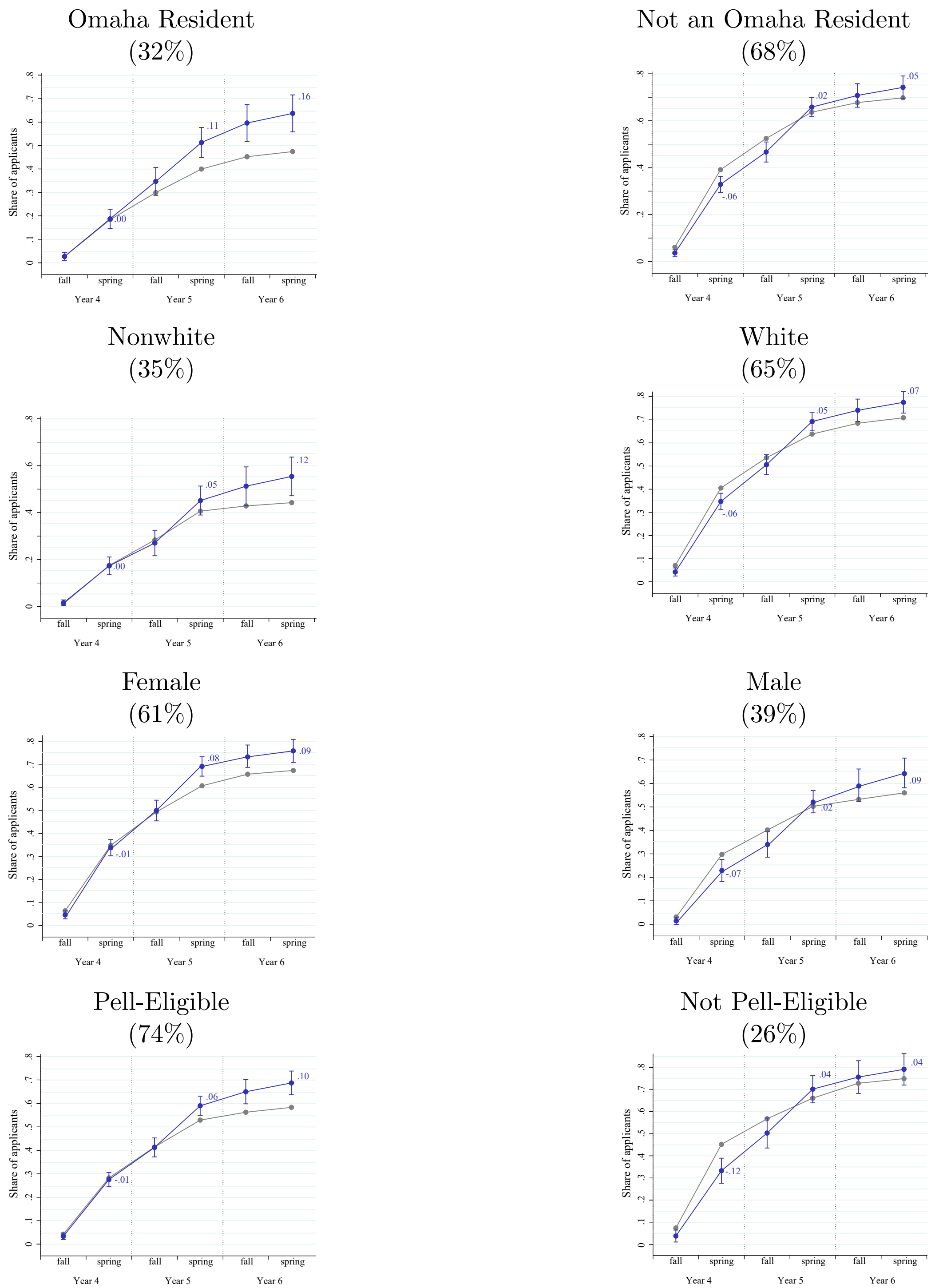


Figure 4 — BA completion in demographic subgroups. *Notes:* This figure plots mean degree completion rates by treatment status and subgroup for the four-year strata. Grey lines plot completion rates for control applicants; blue lines plot the sum of control means and strata-adjusted treatment effects. Whiskers mark 95 percent confidence intervals. Samples differ by year.

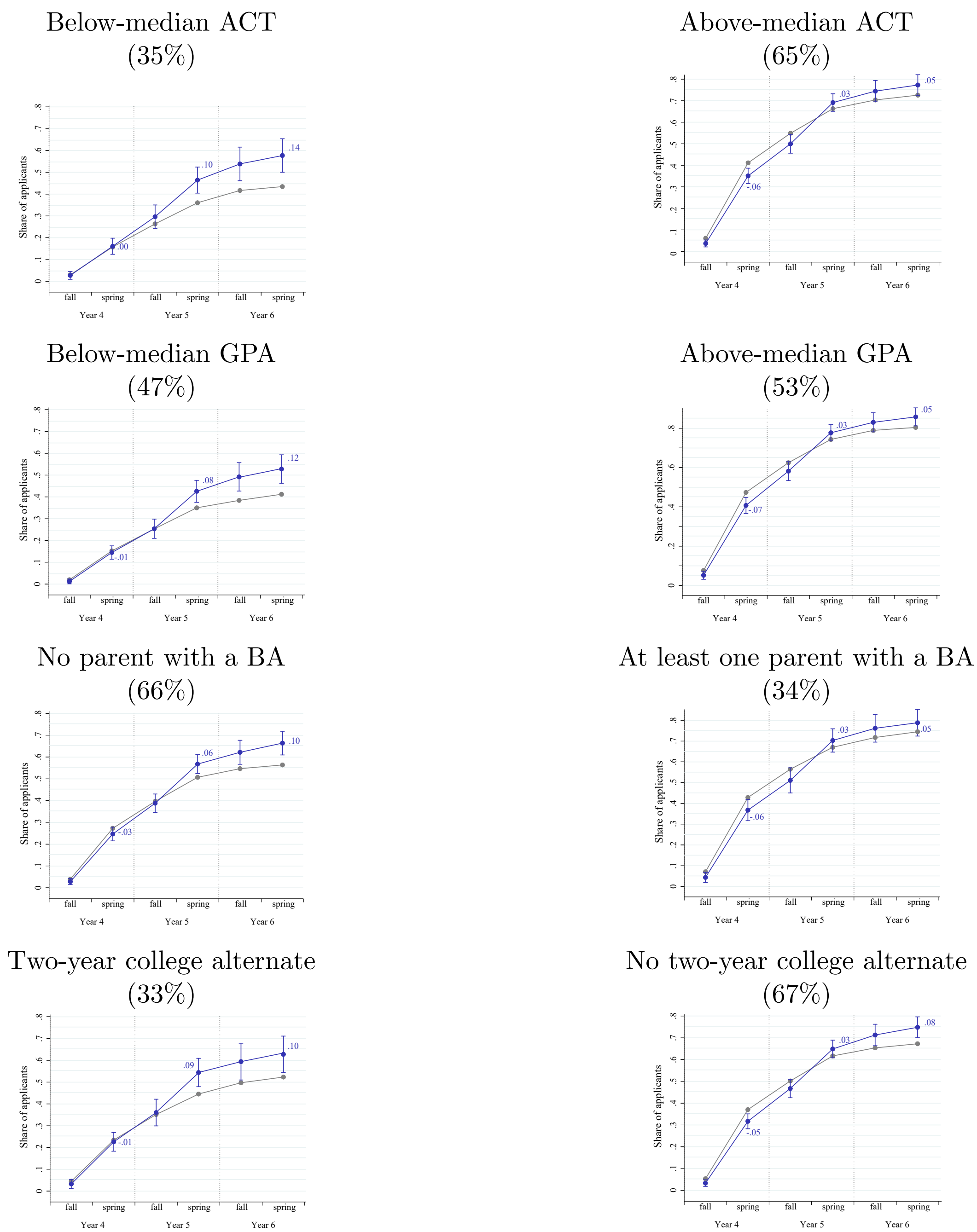
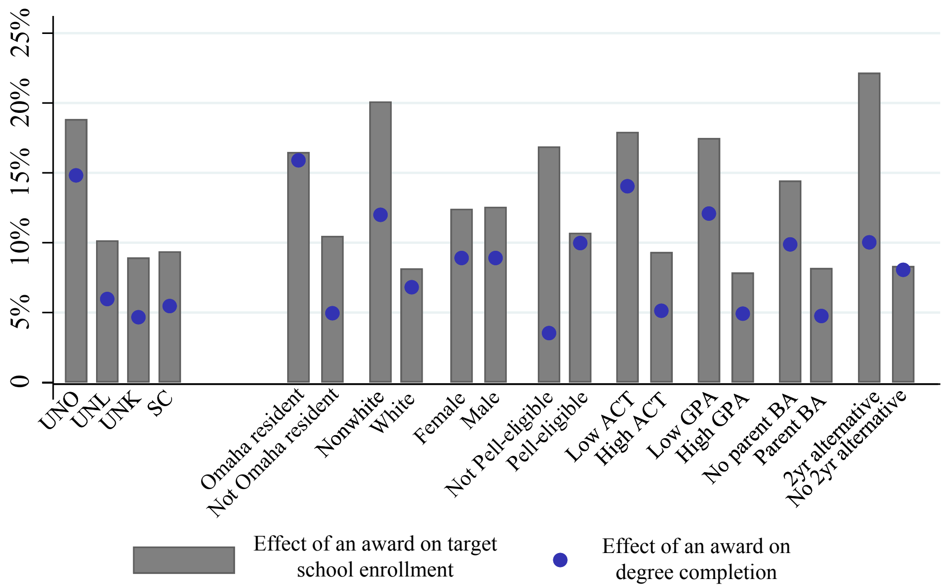


Figure 5 — BA completion in college readiness subgroups. *Notes:* This figure plots mean degree completion rates by treatment status and subgroup for the four-year strata. Grey lines plot completion rates for control applicants; blue lines plot the sum of control means and strata-adjusted treatment effects. Whiskers mark 95 percent confidence intervals. Samples differ by year. The median ACT score for Nebraska test-takers is 21. The median high school GPA for the lottery sample is 3.49. STBF award applicants were asked to indicate their first choice ("target school") and to rank alternatives. "Two-year college alternate" indicates that a student ranked a two-year college among their alternative target schools on the STBF application.

A. Target school enrollment by target campus and subgroup



B. Destiny distributions for target compliers

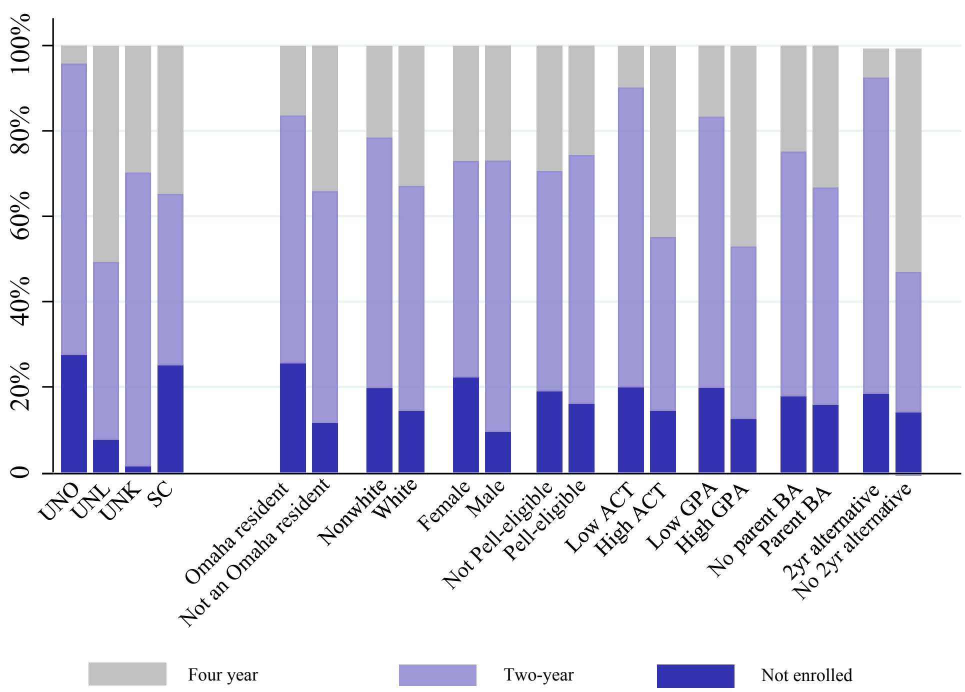


Figure 6 — First-stage estimates and counterfactual destinies for target-school compliers in four-year strata. *Notes:* Panel A plots the first-stage effect of awards on target-campus enrollment for scholarship applicants in four-year strata. Bar height in Panel A measures the share of four-year applicant subgroups who are target-school compliers; target school compliers are applicants who enroll in their target school when awarded scholarships but not otherwise. Panel B shows the distribution of enrollment by school type for target-school compliers when compliers are untreated. Enrollment status uses first-year data only. Subgroups are the union of those shown in Figures 4 and 5.

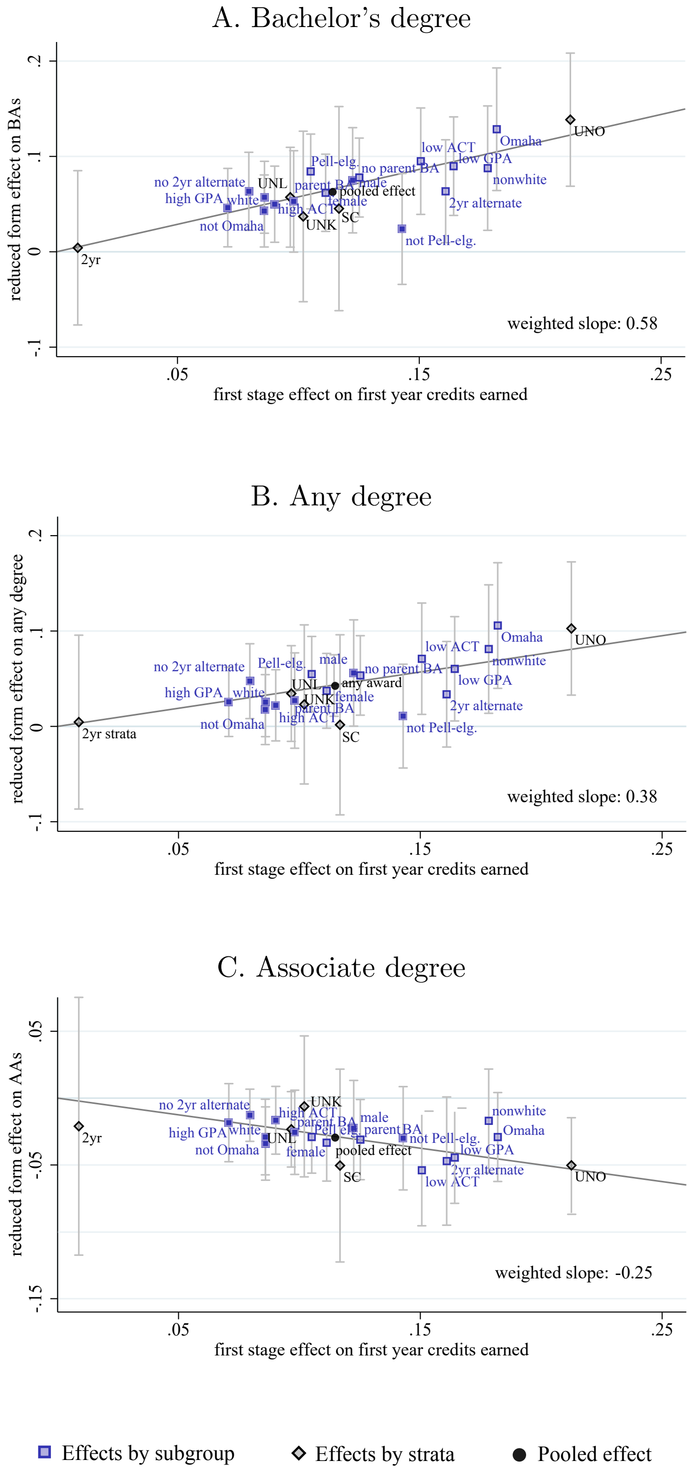


Figure 7 — Visual IV estimates of the effect of award-induced four-year credit completion on degrees. *Notes:* This figure plots reduced-form offer effects against first-stage offer effects, estimated in separate regressions by strata, subgroup, and in the randomization sample at-large. The x-axis shows effects on credit-hours earned at any four-year institution in the first post-application year. Credit-hours are scaled by 24, the STBF standard for full-time enrollment. The y-axes shows effects on degree completion. Regression lines in each panel are constrained to run through the origin and estimated using data weighted by strata and subgroup sample sizes. The sample is restricted to the 2012 and 2013 cohorts. All models control for strata and subgroup main effects. Whiskers mark 95 percent confidence intervals.

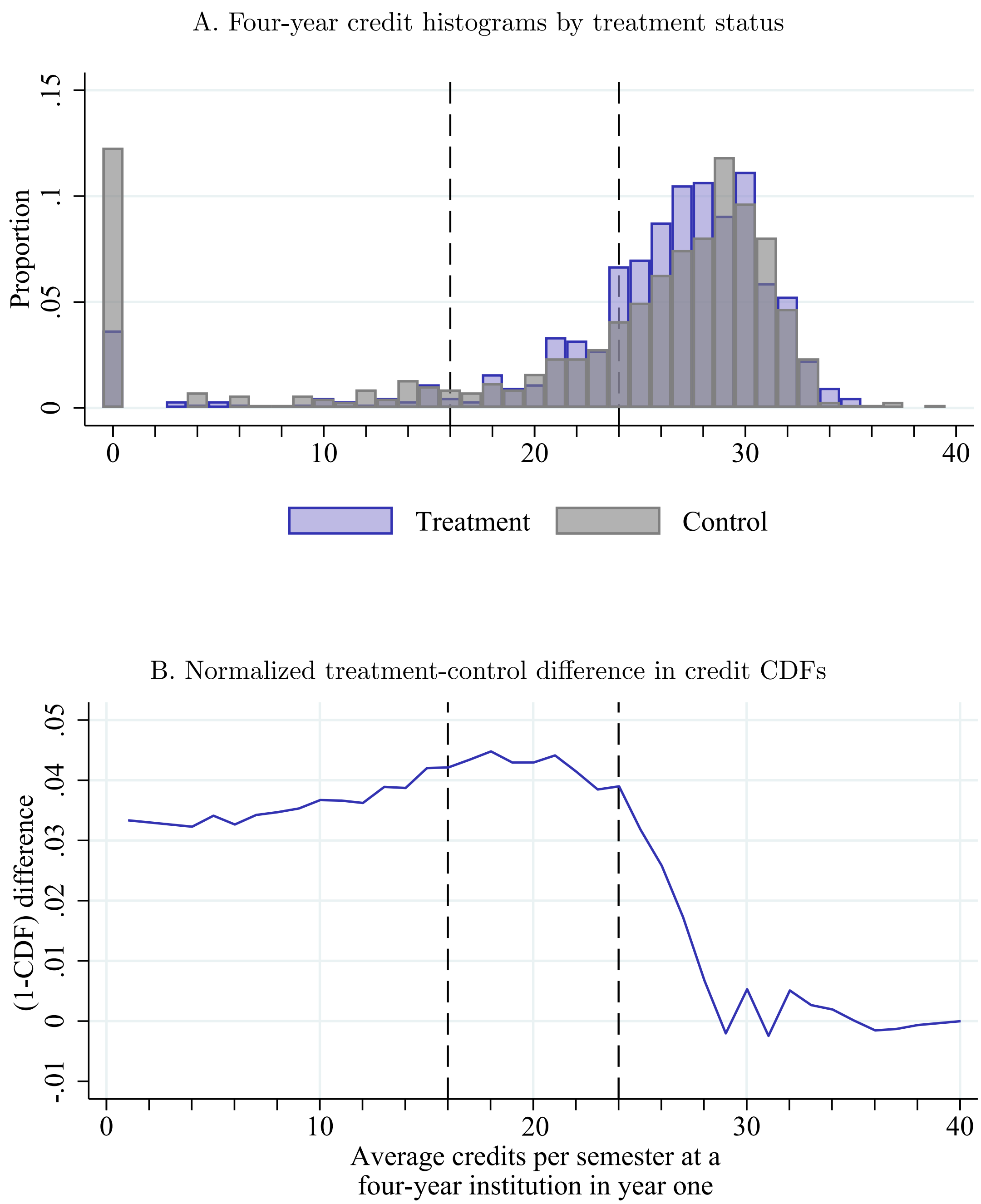


Figure 8 — The distribution of four-year credits by treatment status. *Notes:* Panel A plots the histogram of four-year credits earned in the first post-application year separately by treatment status. Panel B plots the difference in the (negative of the) CDF of four-year credits earned by treatment status, normalized to generate the weighting function described in the text. The x-axis in panel B measures the likelihood that an award shifts applicants from completing fewer than s credit(s) to completing at least s credit(s). Vertical lines mark 16 and 24 credits completed. The sample includes 2012 and 2013 applicant cohorts in the four-year strata.

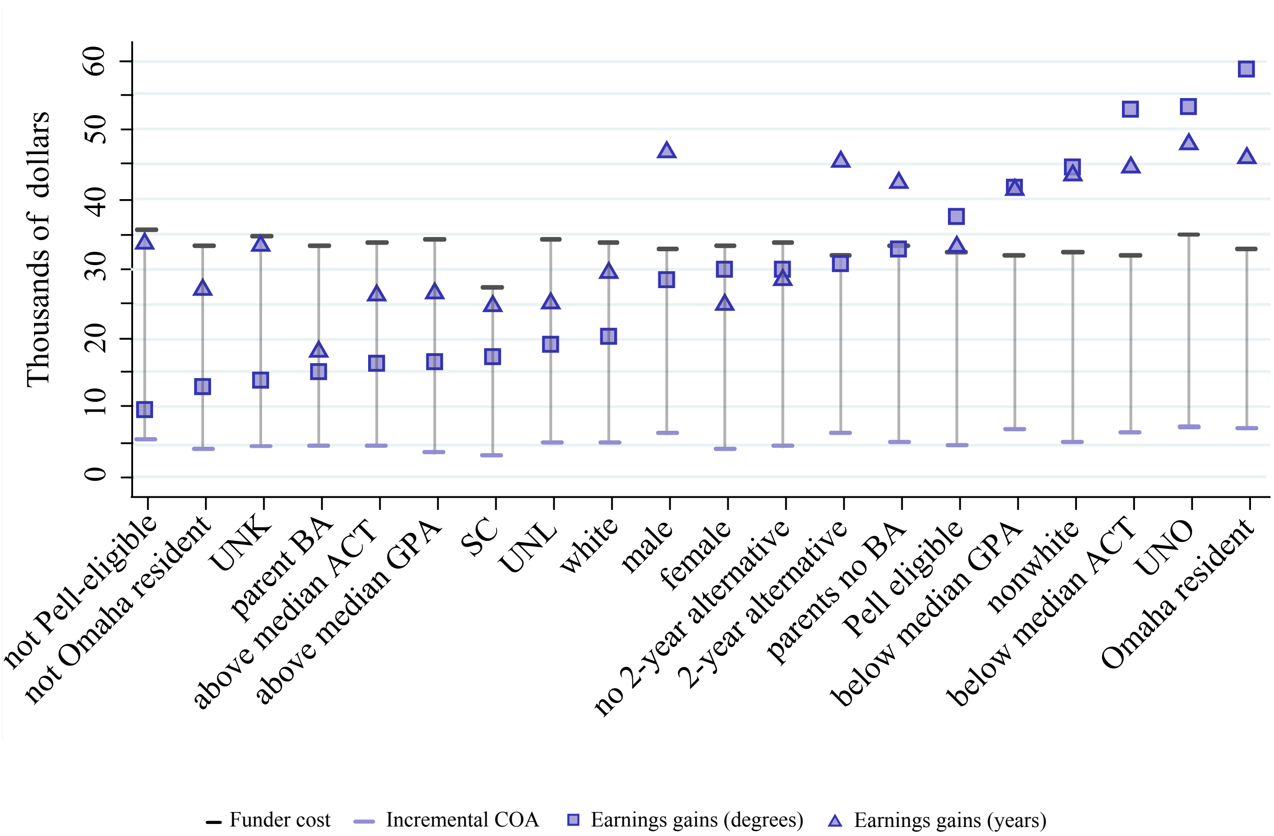


Figure 9 — Earnings gains compared with program costs. *Notes:* This figure compares program costs with estimates of the lifetime earnings generated by award receipt, when the latter are measured by the returns to degree completion and the returns to years of schooling. These two measures of gains differ because awards increase schooling for many who don't finish degrees. Costs are also measured two ways: the lower tick mark indicates the increase in educational spending generated by awards, while the upper tick mark shows average funder cost. Estimates are for the 2012 and 2013 cohorts in four-year strata.

Table 1
Descriptive statistics

			Non-experimental sample		Experimental sample	
	Nebraska HS seniors	Eligible scholarship applicants	Guaranteed award	No award	All	Treatment-control
	(1)	(2)	(3)	(4)	(5)	(6)
Female	0.50	0.62	0.68	0.54	0.62	0.02
						(0.01)
White	0.76	0.63	0.54	0.57	0.66	0.00
						(0.01)
Black	0.07	0.06	0.06	0.11	0.06	0.00
						(0.01)
Hispanic	0.12	0.21	0.27	0.22	0.20	0.01
						(0.01)
Asian	0.03	0.05	0.09	0.04	0.05	-0.01
						(0.01)
Other race	0.02	0.04	0.04	0.05	0.04	-0.00
						(0.00)
Family income ($)	86,605	44,774	37,503	44,073	46,353	-1,131
		[45,178]	[73,675]	[28,233]	[38,911]	(1,226)
EFC ($)	---	2,692	2,026	2,634	2,836	-89
		[3,063]	[2,682]	[3,271]	[3,087]	(75)
Eligible for Pell grant	---	0.75	0.80	0.77	0.74	0.01
						(0.01)
At least one parent attended college	0.71	0.66	0.57	0.64	0.68	0.01
						(0.01)
At least one parent has BA	0.44	0.31	0.27	0.28	0.32	0.00
						(0.01)
Lives in Omaha	---	0.30	0.35	0.38	0.28	-0.01
						(0.01)
Took ACT	.85	0.94	0.94	0.90	0.94	0.00
						(0.01)
Composite ACT score	21.61	21.87	22.67	20.18	21.94	-0.13
		[4.47]	[4.48]	[4.14]	[4.45]	(0.10)
High school GPA	---	3.44	3.61	3.11	3.45	0.01
		[0.43]	[0.36]	[0.40]	[0.42]	(0.01)
F-statistic						0.01
p-value						0.01
# of applicants		11,009	1,667	1,152	8,190	8,190

Notes: This table reports descriptive statistics for the experimental sample and, in the first column, a comparison group of Nebraska high school seniors. Data in column one come from SEER (gender and race), ACS (family income and parent education status), and the ACT National Profile Report (ACT (2012)). Treatment-control differences in column six come from regressions that control for strata dummies (cohort by target college). The sample includes the 2012-2016 applicant cohorts. Missing values for race (6 percent), family income (5 percent), and ACT (7 percent) are imputed from means within strata in the sample of eligible applicants. Standard deviations are reported in brackets. Standard errors for the differences in column six are reported in parentheses.

Table 2
Initial enrollment effects

	Four-year strata				Two-year strata	
			NU 2013 - 2016			
	Control mean	Award effect	Regular award	COS award	Control mean	Award effect
	(1)	(2)	(3)	(4)	(5)	(6)
Any college enrollment	0.961	0.026	0.025	0.028	0.899	0.058
		(0.004)	(0.005)	(0.006)		(0.014)
A. Program type						
Four-year	0.831	0.106	0.119	0.094	0.060	0.038
		(0.008)	(0.010)	(0.012)		(0.015)
Two-year	0.095	-0.067	-0.078	-0.066	0.837	0.007
		(0.006)	(0.007)	(0.009)		(0.020)
Both	0.035	-0.013	-0.016	0.000	0.003	0.013
		(0.004)	(0.005)	(0.007)		(0.005)
B. Sector and location						
Nebraska public	0.874	0.068	0.070	0.067	0.860	0.079
		(0.007)	(0.009)	(0.011)		(0.016)
University of Nebraska	0.677	0.115	0.139	0.124	0.017	0.046
		(0.009)	(0.012)	(0.014)		(0.011)
State college	0.108	0.015	0.002	0.004	0.017	0.012
		(0.005)	(0.004)	(0.005)		(0.008)
Community college	0.121	-0.072	-0.084	-0.057	0.827	0.027
		(0.007)	(0.008)	(0.011)		(0.020)
Out-of-state public	0.024	-0.016	-0.018	-0.013	0.018	-0.016
		(0.003)	(0.004)	(0.005)		(0.006)
Private	0.063	-0.026	-0.026	-0.026	0.021	-0.006
		(0.005)	(0.007)	(0.008)		(0.007)
# of applicants	3,786	6,845	4,350	3,787	705	1,345

Notes: This table reports the effect of scholarship offers on enrollment by the end of the scholarship application year. The sample includes 2012-2016 applicant cohorts. Columns one and two include all four-year targeters. Columns three and four include only NU applicants from 2013-2016 cohorts to capture the effect of COS awards. Column three excludes those who were offered COS awards and only includes students who received an STBF award with mandated LC participation and control applicants. Column 4 only includes those who were offered an LC award, without mandatory LC participation, and control applicants. Outcomes in each panel are mutually exclusive. Students simultaneously enrolled at both Nebraska public colleges and universities and non-Buffett eligible campuses are coded as Nebraska public only. The regressions used to estimate treatment effects control for strata dummies.

Table 3
Degree completion effects

	Four-year strata				Two-year strata	
			NU 2013			
	Control mean	Award effect	Regular award	COS award	Control mean	Award effect
	(1)	(2)	(3)	(4)	(5)	(6)
Bachelor's degree earned	0.629	0.084	0.089	0.083	0.232	0.035
		(0.020)	(0.023)	(0.036)		(0.044)
Associate degree earned	0.079	-0.030	-0.026	-0.041	0.545	-0.014
		(0.010)	(0.011)	(0.016)		(0.050)
Enrolled at four-year college	0.015	-0.002	-0.001	-0.010	0.052	0.010
		(0.005)	(0.006)	(0.009)		(0.023)
No degree earned	0.310	-0.058	-0.066	-0.050	0.386	-0.016
		(0.019)	(0.022)	(0.035)		(0.048)
Enrolled at four-year college	0.058	-0.003	-0.005	-0.026	0.013	0.002
		(0.010)	(0.012)	(0.017)		(0.012)
Total years of schooling	3.950	0.401	0.463	0.204	3.054	0.347
		(0.052)	(0.060)	(0.097)		(0.159)
Years at four-year	3.162	0.648	0.729	0.485	0.749	0.381
		(0.065)	(0.074)	(0.118)		(0.144)
Years at two-year	0.495	-0.215	-0.229	-0.219	2.193	-0.029
		(0.039)	(0.045)	(0.068)		(0.131)
Dual enrollment	0.293	-0.032	-0.037	-0.062	0.112	-0.005
		(0.024)	(0.027)	(0.045)		(0.038)
# of applicants	1,198	2,233	1,721	830	233	395

Notes: This table reports effects on degree completion and years of schooling by the end of year six. Estimated effects on year-six outcomes use data from the 2012 and 2013 cohorts. Columns one and two include all four-year targeters. Columns three and four include only NU applicants from 2013-2016 cohorts to capture the effect of COS awards. Column three excludes those who were offered COS awards and only includes students who received an STBF award with mandated LC participation and control applicants. Column 4 only includes those who were offered an LC award, without mandatory LC participation, and control applicants. Columns five and six use the experimental two-year strata in the 2012 and 2013 cohorts. The regressions control for strata dummies.

Table 4

IV estimates of the effect of initial four-year credits completed on degrees

		2SLS			
	OLS	Just-identified	Strata interactions	Subgroup interactions	Strata and subgroup interactions
	(1)	(2)	(3)	(4)	(5)
A. Bachelor's degree					
Four-year credits earned	0.58	0.59	0.60	0.50	0.48
	(0.02)	(0.14)	(0.12)	(0.13)	(0.11)
First stage					
Any award		0.11			
		(0.01)			
F-stat			17.70	10.01	7.78
Over-identification test		--	0.64	10.74	11.38
Degrees of freedom			4	8	12
p-value			0.96	0.22	0.50
B. Any degree					
Four-year credits earned	0.43	0.37	0.42	0.35	0.32
	(0.02)	(0.14)	(0.12)	(0.14)	(0.12)
Over-identification test		--	1.14	10.12	10.80
p-value			0.89	0.26	0.55
C. Associate degree					
Four-year credits earned	-0.20	-0.26	-0.23	-0.22	-0.23
	(0.02)	(0.10)	(0.07)	(0.09)	(0.07)
Over-identification test		--	0.98	5.16	7.71
p-value			0.91	0.74	0.81

Notes: This table reports 2SLS estimates and over-identification test statistics for models where the outcome is BA completion and the endogenous variable is initial four-year engagement as defined in Figure 7. The just-identified estimate in column 2 uses a single offer dummy as instrument. Estimates in columns 3 to 5 are from over-identified models with instrument sets constructed by interacting award offers with sets of dummies indicated in column headings. The sample is restricted to the 2012 and 2013 cohorts. All regressions control for strata and subgroup main effects.

Table 5

Dynamic exclusion parameter estimates and specification tests

	Strata interactions			Subgroup interactions			Strata and subgroup interactions		
	Year 2	Year 3	Year 4	Year 2	Year 3	Year 4	Year 2	Year 3	Year 4
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
A. Effect of year-t credits on BA completion									
μ_t	0.55	0.64	0.61	0.54	0.68	0.61	0.53	0.66	0.61
	(0.10)	(0.11)	(0.10)	(0.09)	(0.10)	(0.09)	(0.09)	(0.10)	(0.09)
First stage F	18.2	11.8	13.3	9.35	5.49	6.71	7.62	4.53	5.19
Over-id test	7.49	9.5	1.52	3.52	5.88	11.4	10.6	13.7	11.7
p-value	0.058	0.024	0.678	0.897	0.660	0.182	0.474	0.248	0.385
B. Effects of year 1 credits on year-t credits									
ψ_t	1.07	0.91	0.94	0.96	0.76	0.82	0.97	0.77	0.81
	(0.11)	(0.12)	(0.13)	(0.09)	(0.10)	(0.11)	(0.08)	(0.10)	(0.11)
First stage F	22.0	--	--	11.1	--	--	8.47	--	--
Over-id test	3.84	1.41	2.81	18.0	11.5	8.21	21.2	13.3	10.1
p-value	0.279	0.702	0.421	0.021	0.174	0.413	0.031	0.273	0.524
$\psi_t\mu_t$	0.59	0.59	0.57	0.52	0.52	0.50	0.51	0.51	0.49
μ_1		0.61			0.50			0.51	
		(0.12)			(0.11)			(0.10)	

Notes: This table reports IV estimates of the dynamic exclusion model described in section 4.2. The instruments consist of award dummies and interactions with strata and covariates as indicated in the column headings. Parameter μ_t is the effect of four-year college credits completed in year t on BA completion. Parameter ψ_t is the effect of four-year college credits completed in year one on credit completion in year t. Dynamic exclusion implies $\mu_1 = \psi_t\mu_t$. The over-identification test statistics reported in columns 1-3 tests three restrictions; those reported in columns 4-6 test 8 restrictions; those reported in columns 7-9 test 11 restrictions. The sample is restricted to the 2012 and 2013 cohorts in the four-year strata. All regressions control for strata and subgroup dummies.

Table 6
College costs and marginal spending by campus

	Four-year strata	NU target campuses			State Colleges
		UNL	UNO	UNK	
	(1)	(2)	(3)	(4)	(5)
A. College costs					
Treated					
Funder cost	33.57	34.01	34.87	34.54	27.40
Cost of attendance (COA)	33.70	36.50	32.14	33.56	27.88
Years of college	4.30	4.35	4.46	4.27	4.09
Cost per year of college	7.57	8.25	7.02	7.37	6.66
Control					
Cost of attendance (COA)	28.03	30.88	25.00	29.16	24.32
Years of college	3.95	4.06	3.96	3.97	3.84
Cost per year of college	7.03	7.61	6.31	7.34	6.34
B. Marginal costs					
(1) Funder spending per extra degree	399.61	568.80	238.20	737.95	500.07
(2) Marginal COA per extra degree	67.49	94.06	48.76	93.91	65.03
Marginal share (2)/(1)	0.17	0.17	0.20	0.13	0.13
C. Decomposition of marginal spending					
Award effects on:					
(1) Log cost of attendance	0.23	0.21	0.32	0.11	0.19
	(0.03)	(0.04)	(0.06)	(0.06)	(0.08)
(2) Log years of college	0.11	0.09	0.15	0.07	0.10
	(0.02)	(0.02)	(0.03)	(0.04)	(0.05)
(3) Log cost per year of college	0.12	0.12	0.17	0.03	0.09
	(0.02)	(0.03)	(0.04)	(0.04)	(0.06)
Share of marginal spending due to increased years in college (2)/(1)	0.48	0.43	0.48	0.68	0.54
# of applicants	2,218	953	649	315	301

Notes: This table reports award effects on degree costs. Panels A and B show statistics including students who have zero years of schooling and thus zero cost of attendance; Panel C excludes these students. Panel A reports mean cost and years of attendance for control students. Values for treatment students are the sum of control means and strata adjusted treatment effects. Panel B reports funder spending and incremental cost of attendance per bachelor's degree created by taking the ratio of per-student spending to the strata-adjusted award effect on BAs. The third row of Panel B reports the ratio of the first two rows. The first three rows in Panel C report results from regressions of log COA, log years, and log cost per year on a dummy for winning a scholarship in the given sample. These regressions include strata dummies. Estimates are for the 2012 and 2013 cohorts in four-year strata. Dollars values are reported in thousands.

Table 7
Award effects on lifetime earnings

	Control (1)	Treatment (2)	Difference (3)
Years of schooling			
3% discount rate	1,181	1,215	33.64
5% discount rate	721	735	13.22
Degree attainment			
3% discount rate	1,189	1,216	29.21
5% discount rate	734	747	13.86

Notes: This table shows the effect of an award on predicted lifetime earnings (in thousands of dollars), computed as described in section 5.1. Estimates are for the 2012 and 2013 cohorts in four-year strata.

A Data Appendix

A.1 Application Data

The STBF scholarship application collects detailed information on applicants' baseline characteristics. Academic measures such as GPA are gathered primarily from high school transcripts. We standardize GPAs to a 4.0 scale using the grade conversion formula provided by the University of Nebraska-Lincoln. We also consider students' ACT score. Since not all high schools report students' ACT scores on transcripts, transcript data are supplemented with self-reported scores from the application survey for 54 percent of the experimental sample.[24]

Most of the financial and demographic data used here come from applicants' Student Aid Reports (SARs). These reports are available for all STBF applicants who filed the Free Application for Federal Student Aid (FAFSA). SARs contain responses to more than 100 FAFSA questions regarding students' financial resources and family structure, including family income, parents' marital status, and parents' education. Roughly three percent of scholarship applicants are undocumented immigrants, who are ineligible for federal financial aid and therefore cannot file the FAFSA. STBF permits these students to submit an alternate form called the College Funding Estimator (CFE). The CFE is published by the EducationQuest Foundation, a non-profit organization in Nebraska, and gathers a similar, though less detailed, set of information.

Neither SARs nor CFEs report students' race, and the scholarship application did not collect this variable until the 2014 cohort. Supplemental data on race were obtained from the Nebraska Department of Motor Vehicles. Over 85 percent of the randomization sample was successfully matched to driver's license records.

A.2 Financial Aid Data

Nebraska's public colleges and universities provided detailed information on their students' financial aid packages. These data report costs of attendance, grants, loans, and Federal Work Study aid. While all schools report federal loans, most do not report private loans, which may be obtained directly from lenders without involving financial aid officers. We therefore exclude private loans

[24] In Nebraska, the majority of students take the ACT rather than the SAT. In 2012-2013, 70 percent of Nebraska high school students took the ACT, compared with the national average of 52 percent.

from our analysis. For most STBF applicants, however, federal loans offer the lowest available interest rate and therefore account for the vast majority of borrowing.

Cost of Attendance

Publicly available IPEDS institutional characteristics data were used to estimate a sticker price of college for every student in our experimental sample. The sticker price calculation includes in-state tuition, fees, and a books and supplies stipend. The institutional characteristics dataset in each year from IPEDS has nearly full coverage of tuition and fees for schools attended by students in our experimental sample. There is only one school for whom we do not have tuition and fees for – this is a special case in which the student transferred to an out-of-state certificate school. This school's cost of attendance varies greatly based on certificate program, so we drop the student from the sample.

The IPEDS data are missing a books and supplies cost value for 8 percent of the sample. In these cases we impute costs using the mean books and supplies costs for students in the same calendar year and college type (four-year vs two-year and for-profit vs not for profit).

We calculate each student's sticker price by matching credits attempted per term to the cost per credit at the school attended in every year of attendance. Importantly, we use credits attempted, as opposed to credits earned because a student is charged for every credit attempted, whether or not they pass the course. As above, IPEDS has nearly full coverage of cost per credit for schools attended by our experimental sample. Every school that reports tuition also reports cost per credit. We also calculate the total cost based on credits attempted for each student at each school. When this credit-based cost exceeds the school's reported tuition, the cost variable is assigned the full-time tuition value. Each student's sticker price is then estimated by summing credits-based cost per term, a books and supplies stipend, and the school-reported fees in each academic year.

A.3 Education Outcome Variables

Over 90 percent of experimental subjects enrolled in Nebraska's public colleges and universities. We match STBF applicants to administrative data provided by these schools using names, dates of birth, and the last four digits of Social Security Numbers (SSNs). To measure enrollment at out-of-state and private institutions, we match applicants to National Student Clearinghouse (NSC) data using names and dates of birth. Though the NSC captures more than 91 percent of enrollment nationwide (and more than 99 percent at four-year public institutions), its name-based match has limitations, as Dynarski, Hemelt and Hyman (2015) detail. Roughly four percent of experimental applicants have enrollment at Nebraska's public colleges and universities that does not appear in our NSC-matched sample. These students are disproportionately nonwhite.

Enrollment Measures

Many of the enrollment outcomes reported in this paper are enrollment indicators. Table 2, for example, reports effects on the probability of enrollment in year one. We define follow-up windows to match the federal financial aid year, which runs from July 1 to June 30. Within each window, we force binary enrollment outcomes to be mutually exclusive. Students who enroll at both two- and four-year institutions are coded as "any four-year" enrollment. Likewise, those who enroll at in-state public colleges do not contribute to the out-of-state or private categories, and selectivity outcomes are defined by the most selective institution attended.

We also track cumulative credit completion. Most of these data come from Nebraska's public colleges and universities. Credits for the seven percent of applicants who attend out-of-state or private colleges are imputed using the NSC's coarse enrollment status variable: an indicator for whether students were enrolled full-time, half-time, or less than half-time. Imputed credit is the predicted value from a regression of credits on enrollment status, degree program, academic term, and cohort. Less than two percent of applicants attend out-of-state or private schools that do not report the full-time enrollment indicator to the NSC. These students are coded as enrolled full time when the full-time enrollment share at their chosen school is at least 85 percent, as reported by IPEDS.

Years of Schooling Data

Years of schooling variables are derived from term-wise enrollment status as reported by Nebraska's public colleges and universities, or in the NSC when the former are not available. These indicate "attempted enrollment" at an institution (as opposed to measuring credits completed). Using data from our NSC-matched sample, we generate a binary enrollment dummy for each student in every possible term equal to one if the student appears as enrolled (at any level) in any institution.

Degrees Data

Degree completion indicators come from Nebraska's public colleges and universities, or the NSC when the former is not available. NSC and the colleges report completion of associate degrees and bachelor's degrees for each student, as well as the year and term in which degree requirements were completed.

A.4 Earnings Imputation

The earnings imputation uses an extract of Nebraska-born men aged 18 to 70 in ACS data from 2012-2016; the sample is limited to employed men working full time (greater than 35 hours per week) and omits full-time students.

This section completes the description of the lifetime earnings imputation sketched in Section 5.1. The first parameterization of the relationship between schooling and earnings sets $f(s_i) = s_i$ as in the traditional Mincerian setup. Let $\hat{y}_{se}$ equal the predicted log annual earnings of a worker with s years of schooling and $e \equiv \max\{\text{age}-s-6, 0\}$ years of potential experience who works 50 weeks per year at 40 hours per week. Under this parameterization of potential experience, a student who enters the workforce at high school completion has $e = 0$ at age 18, and a student who attends four years of college has $e = 0$ at age 22. The PDV of lifetime predicted earnings over the course of 52 potential working years is calculated as:

$$\hat{Y}_s = \sum_{e=0}^{51-c} \frac{\exp[\hat{y}_{se}]}{(1+r)^{e+c}}, \tag{11}$$

where $c = s - 12$, and r is the discount rate. The second specification assumes that years of college affect earnings only insofar as they yield a degree. Here, we specify $f(s)$ as a pair of dummy variables indicating two-year or four-year degree attainment, with high school graduates as the omitted group. In this specification, each year of college reduces potential experience and career length but only increases predicted earnings if it leads to a degree. Let $\hat{y}_{sde}$ equal the predicted log earnings of a worker with s years of completed schooling, with highest degree attained $d \in \{HS, AA, BA\}$, and with e years of potential experience. The PDV of predicted lifetime earnings in this parameterization substitutes $\hat{y}_{sde}$ for $\hat{y}_{se}$ in equation (11). In this model, students who are induced by awards to remain in school longer, but fail to complete a degree, may suffer a lifetime earnings loss as a result of treatment.

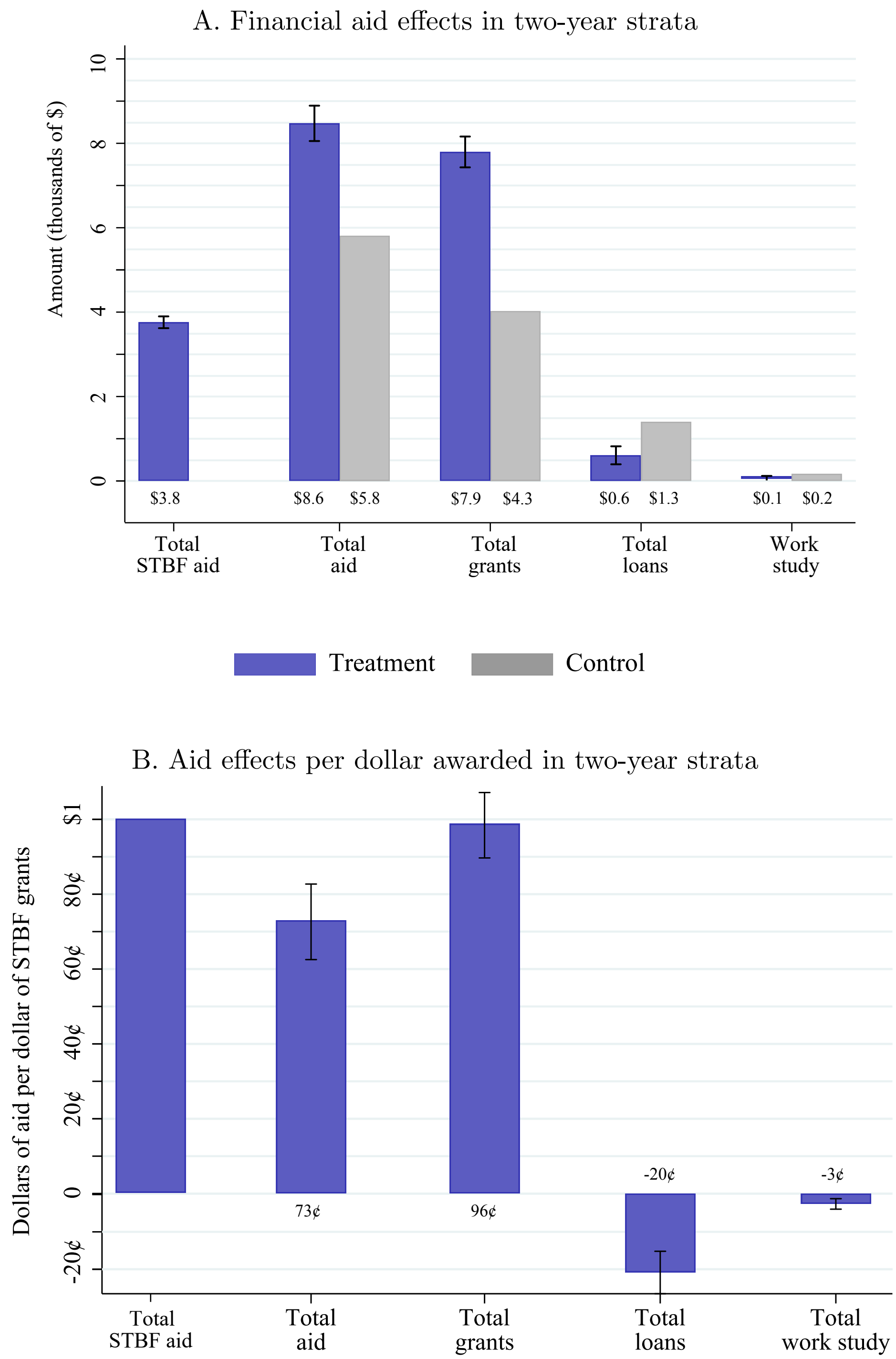


Figure A1 — Award effects on year one post-secondary aid for applicants in two-year strata. *Notes:* This figure shows the effect of an STBF award offer on aid of various kinds in the year following scholarship application. The sample is restricted to students who targeted two-year colleges and enrolled at a Nebraska public college or university. Whiskers mark 95 percent confidence intervals for the treatment effect of an award offer. The regressions used to estimate treatment effects control for strata dummies.

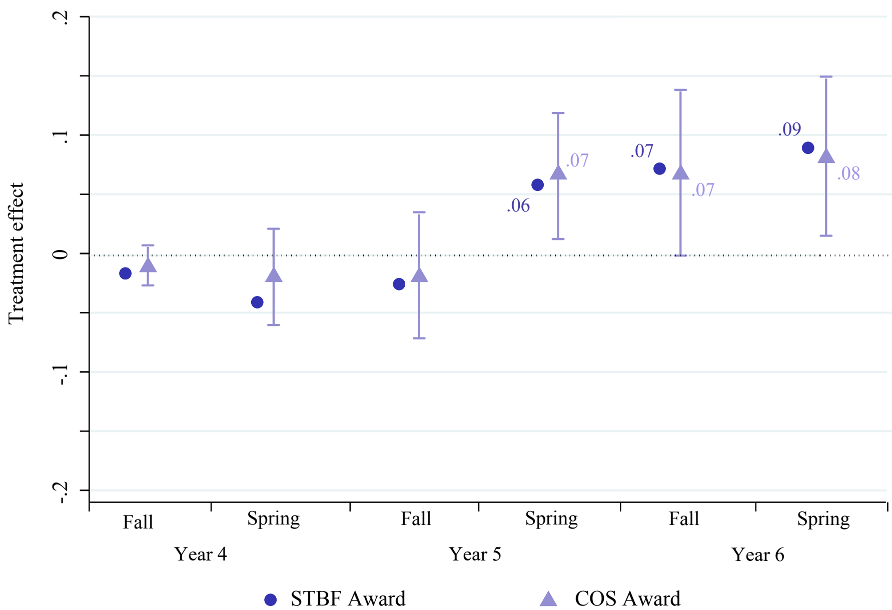


Figure A2 — Bachelor's degree effects by award type. *Notes*: This figure plots the effect of awards with and without learning community participation on six-year degree completion for applicants targeting four-year campuses. Awards without an LC mandate are called College Opportunity Scholarships (COS). Whiskers mark 95 percent confidence intervals. The samples used to estimate treatment effects differ by year.

Table A1

Baseline sample selection

	Control (1)	STBF Award (2)	COS Award (3)	Total (4)		Control (5)	STBF Award (6)	COS Award (7)	Total (8)		Control (9)	STBF Award (10)	COS Award (11)	Total (12)
2012 Total	**495**	**504**		**999**	**2013 Total**	**936**	**484**	**209**	**1,629**	**2014 Total**	**860**	**606**	**211**	**1,677**
Four-Year Strata	424	431		855	Four-Year Strata	774	395	209	1,378	Four-Year Strata	726	469	211	1,406
UNK	63	64		127	UNK	71	66	51	188	UNK	73	64	48	185
UNL	173	175		348	UNL	369	153	89	611	UNL	413	167	93	673
UNO	141	142		283	UNO	181	123	69	373	UNO	143	140	70	353
State Colleges	47	50		97	State Colleges	153	53	0	206	State Colleges	97	98	0	195
Two-Year Strata	71	73		144	Two-Year Strata	162	89	0	251	Two-Year Strata	134	137	0	271
2015 Total	**1,033**	**624**	**220**	**1,877**	**2016 Total**	**1,167**	**619**	**222**	**2,008**	**Total**	**4,491**	**2,837**	**862**	**8,190**
Four-Year Strata	876	465	220	1,561	Four-Year Strata	986	437	222	1,645	Four-Year Strata	3,786	2,197	862	6,845
UNK	103	65	48	216	UNK	122	51	49	222	UNK	432	310	196	938
UNL	450	168	91	709	UNL	565	158	91	814	UNL	1,970	821	364	3,155
UNO	223	130	81	434	UNO	212	140	82	434	UNO	900	675	302	1,877
State Colleges	100	102	0	202	State Colleges	87	88	0	175	State Colleges	484	391	0	875
Two-Year Strata	157	159	0	316	Two-Year Strata	181	182	0	363	Two-Year Strata	705	640	0	1,345

Notes: This table reports sample counts by applicant cohort and target college. The sample contains applicants who were subject to random assignment. COS awards were offered only in the 2013-2016 University of Nebraska strata. Two-year college strata include Central Community College, Metropolitan Community College, Mid-Plains Community College, Northeast Community College, Southeast Community College, and Western Nebraska Community College strata. The State College strata include Chadron State, Peru Sate, and Wayne State strata.

Table A2

Descriptive statistics by target college

	Four-Year Strata								Two-Year Strata	
	UNL		UNO		UNK		State Colleges			
	All	Treatment - control	All	Treatment - control	All	Treatment - control	All	Treatment - control	All	Treatment - control
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Female	.55	.037	.64	.007	.71	-.014	.65	-.003	.61	.027
		(.021)		(.025)		(.035)		(.033)		(.026)
White	.67	-.005	.47	-.014	.77	-.004	.83	.024	.69	.013
		(.020)		(.025)		(.032)		(.025)		(.024)
Black	.07	.004	.09	.008	.02	-.021	.03	.002	.02	.002
		(.011)		(.015)		(.008)		(.011)		(.008)
Hispanic	.16	.005	.30	.032	.19	.033	.10	-.013	.20	-.008
		(.015)		(.023)		(.030)		(.020)		(.022)
Other race	.05	-.005	.09	-.010	.01	-.001	.01	-.005	.06	-.011
		(.009)		(.014)		(.007)		(.003)		(.012)
Family income ($)	49,374	-4,785	42,597	736	50,141	-626	48,335	2,179	42,444	570
	[29,058]	(3,091)	[27,886]	(1,359)	[39,452]	(3,125)	[33,960]	(2,185)	[33,379]	(1,736)
EFC ($)	3,051	2	2,389	-148	3,212	-157	3,167	-59	2,594	-159
	[3,115]	(135)	[2,914]	(150)	[3,126]	(238)	[3,195]	(216)	[3,096]	(162)
At least one parent attended college	.74	.011	.57	-.014	.73	-.028	.75	.029	.59	.046
		(.018)		(.025)		(.034)		(.030)		(.026)
At least one parent earned a bachelor's degree	.40	-.010	.25	.003	.33	-.012	.36	-.009	.18	.029
		(.021)		(.022)		(.035)		(.033)		(.021)
Took ACT	.98	-.004	.95	.001	.98	-.007	.98	-.000	.80	.011
		(.007)		(.011)		(.012)		(.009)		(.022)
Composite ACT score	23.8	-.23	21.1	-.28	22.2	-.55	21.7	-.09	18.9	.42
	[4.3]	(.18)	[4.6]	(.23)	[3.9]	(.28)	[3.8]	(.27)	[3.4]	(.19)
High school GPA	3.56	-.017	3.34	-.006	3.52	.041	3.48	-.006	3.26	.053
	[.38]	(.016)	[.41]	(.021)	[.41]	(.030)	[.41]	(.029)	[.41]	(.022)
F-statistic		1.10		.97		1.64		.61		1.19
p-value		.35		.48		.06		.85		.28
# of applicants	2,791	2,791	1,575	1,575	742	742	875	875	1,345	1,345

Notes: This table reports descriptive statistics by target college for the 2012-2016 cohorts. See Table 1 notes for variable definitions and descriptions.

Table A3
Descriptive statistics for Omaha residents

		Four-	NU Campuses			State	Two-
	All	Year	UNL	UNO	UNK	Colleges	Year
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
female	.65	.65	.62	.66	.88	.74	.61
White	.42	.43	.49	.37	.62	.54	.26
Black	.16	.17	.20	.14	.15	.17	.09
Hispanic	.28	.27	.21	.33	.19	.19	.36
other race	.09	.08	.05	.10	.04	.02	.27
family income ($)	43,484	43,775	46,937	39,945	58,522	47,555	40,390
	[26,898]	[26,971]	[27,399]	[25,241]	[33,693]	[30,708]	[26,032]
EFC ($)	2,266	2,312	2,568	1,971	3,548	2,925	1,769
	[2,886]	[2,897]	[2,926]	[2,727]	[3,254]	[3,647]	[2,729]
at least one parent attended college	.58	.61	.71	.51	.69	.59	.33
at least one parent earned a bachelor's degree	.28	.29	.38	.21	.42	.30	.11
took ACT	.91	.94	.95	.94	.96	.89	.66
composite ACT score	20.9	21.3	22.7	20.2	21.7	20.0	16.8
	[4.7]	[4.7]	[4.4]	[4.7]	[3.6]	[3.9]	[3.2]
high school GPA	3.25	3.27	3.36	3.22	3.13	3.11	3.04
	[.39]	[.39]	[.39]	[.39]	[.43]	[.35]	[.34]
# of applicants	2,268	2,067	686	972	43	85	201

Notes: This table reports descriptive statistics by target college for Omaha residents the 2012-2016 cohorts. An Omaha resident is any student who listed an Omaha home address on their STBF application. See notes for Table 1 for variable definitions and descriptions.

Table A4

Award effects on years of schooling and degree completion by subgroup

	BA Completion		Years at any school		Years at four-year		Years at two-year	
	Control mean	Program effect	Control mean	Program effect	Control mean	Program effect	Control mean	Program effect
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. Demographic subgroups								
Omaha resident	.474	.156	3.817	.554	2.898	.931	.605	-.283
		(.038)		(.111)		(.127)		(.076)
Not Omaha resident	.698	.047	4.008	.327	3.279	.510	.446	-.179
		(.023)		(.057)		(.074)		(.046)
Nonwhite	.443	.120	3.903	.524	2.888	.862	.748	-.350
		(.038)		(.115)		(.136)		(.086)
White	.709	.065	3.970	.355	3.278	.553	.387	-.146
		(.022)		(.056)		(.072)		(.042)
Male	.560	.086	3.853	.548	3.132	.755	.496	-.195
		(.034)		(.092)		(.111)		(.065)
Female	.673	.085	4.012	.311	3.181	.588	.494	-.234
		(.024)		(.062)		(.079)		(.050)
Pell-eligible	.583	.103	3.925	.389	3.145	.592	.503	-.183
		(.024)		(.065)		(.080)		(.049)
Not Pell-eligible	.745	.038	4.001	.426	3.191	.791	.475	-.298
		(.034)		(.083)		(.109)		(.065)
B. College readiness subgroups								
Below-median ACT	.434	.144	3.753	.560	2.638	.960	.809	-.379
		(.037)		(.112)		(.131)		(.084)
Above-median ACT	.726	.053	4.047	.306	3.421	.475	.339	-.130
		(.023)		(.056)		(.071)		(.041)
Below-median GPA	.412	.120	3.781	.509	2.719	.925	.779	-.380
		(.032)		(.096)		(.111)		(.067)
Above-median GPA	.804	.051	4.086	.312	3.518	.420	.266	-.080
		(.022)		(.053)		(.072)		(.044)
Two-year college considered	.523	.100	3.884	.534	2.676	.851	.923	-.388
		(.040)		(.111)		(.139)		(.103)
No two-year considered	.673	.083	3.977	.352	3.359	.585	.320	-.160
		(.023)		(.059)		(.070)		(.035)
No parent with a BA	.564	.098	3.874	.506	2.984	.794	.597	-.270
		(.026)		(.071)		(.085)		(.054)
Parent with a BA	.745	.046	4.084	.225	3.475	.383	.315	-.108
		(.030)		(.075)		(.098)		(.054)
C. Target campus strata								
UNL strata	.692	.060	4.058	.291	3.342	.461	.391	-.108
		(.029)		(.073)		(.093)		(.056)
UNO strata	.478	.146	3.957	.591	2.916	.999	.727	-.418
		(.038)		(.109)		(.129)		(.083)
UNK strata	.731	.047	3.970	.378	3.216	.661	.351	-.186
		(.049)		(.125)		(.161)		(.088)
SC strata	.635	.055	3.840	.340	3.033	.419	.498	-.123
		(.058)		(.150)		(.182)		(.105)

Notes: This table shows a breakdown of outcomes by student subgroup. Regressions estimates control for strata. Estimates are for the 2012 and 2013 cohorts in the four-year strata in the indicated subgroup.

Table A5
Estimated Earnings Function

	(1)	(2)	(3)	(4)
Years of schooling (schooling)	0.144	0.157		
	(.003)	(.004)		
Associate degree (AA)			0.243	0.237
			(.019)	(.025)
Bachelor's degree (BA)			0.679	0.743
			(.015)	(.021)
Years of experience (experience)	0.014	0.028	0.014	0.015
	(.000)	(.003)	(.000)	(.001)
Years of experience squared	-0.094	0.036	-0.093	-0.077
(Years of experience^2) / 100	(.000)	(.000)	(.004)	(.006)
Experience * schooling		-0.001		
		(.000)		
Experience squared * schooling		-0.009		
		(.002)		
AA * experience				-0.003
				(.001)
BA * experience				-0.003
				(.001)
AA * experience squared				0.004
				(.011)
BA * experience squared				-0.042
				(.010)
Constant	4.989	4.790	6.755	6.723
	(.044)	(.060)	(.013)	(.037)
R^2	0.294	0.297	0.298	0.299
N	19,099	19,099	19,099	19,099

Notes: This table reports estimates of the Mincerian model used to predict lifetime earnings, that is, equation 10, described in Section 5.1. The sample is restricted to Nebraska-born men aged 18-70 in the American Community Survey who work full-time for wages. The first and second columns report estimates constructed using a linear parametrization for schooling; the third and fourth show estimates of a model using dummies for degrees. The years of experience variable is centered to be mean zero. Estimates without schooling-experience interaction terms are reported for reference. Predicted earnings are computed using the estimates in columns 2 and 4.

Table A6

Estimates of award effects on costs and lifetime earnings by subgroup

	Costs ($K)		Earnings ($K)	
	Funder	Incremental COA	Degrees	Years
	(1)	(2)	(3)	(4)
	A. Demographic subgroups			
Omaha resident	33.43	7.54	58.99	46.28
	(1.02)	(1.27)		
Not an Omaha resident	33.61	4.73	13.78	27.53
	(0.59)	(0.84)		
Nonwhite	32.74	5.81	45.06	43.82
	(1.04)	(1.34)		
White	33.94	5.48	20.94	29.94
	(0.58)	(0.82)		
Male	33.35	6.84	29.00	47.11
	(0.84)	(1.12)		
Female	33.76	4.76	30.48	25.40
	(0.65)	(0.91)		
Pell-eligible	32.60	5.25	38.01	33.65
	(0.65)	(0.81)		
Not Pell-eligible	35.96	6.07	10.52	34.11
	(0.77)	(1.38)		
	B. College readiness subgroups			
Below-median ACT	32.40	6.84	53.27	44.95
	(0.95)	(1.15)		
Above-median ACT	34.20	5.13	17.10	26.74
	(0.60)	(0.87)		
Below-median GPA	32.50	7.51	42.15	41.76
	(0.84)	(1.02)		
Above-median GPA	34.39	4.07	17.33	27.03
	(0.64)	(0.94)		
Two-year college considered	32.38	7.13	31.30	55.75
	(1.03)	(1.28)		
No two-year considered	34.15	4.99	30.49	28.93
	(0.59)	(0.84)		
No parent with a BA	33.40	5.70	33.38	42.76
	(0.66)	(0.89)		
Parent with a BA	33.86	5.26	15.91	18.73
	(0.81)	(1.14)		
	C. Target campus strata			
UNL strata	34.01	5.62	19.80	25.60
	(0.77)	(1.11)		
UNO strata	34.87	7.14	53.65	48.25
	(1.04)	(1.33)		
UNK strata	34.54	4.40	14.71	33.81
	(0.99)	(1.77)		
SC strata	27.40	3.56	18.04	25.22
	(1.38)	(1.70)		

Notes: This table reports the effects of an award on costs and earnings by subgroup: the information visualized in 9. Details of the specifications can be found in Section 5. The sample is restricted to four-year strata students in the 2012 and 2013 cohorts.