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ABSTRACT

ProPelled: The Effects of Grants on Graduation, Earnings, and Welfare*

We estimate effects of the Pell Grant - the largest U.S. federal grant for college students - using administrative data from Texas public colleges and a discontinuity in grant generosity for low-income students. Within four-year institutions, eligibility for additional grant aid significantly increases first-time students' degree completion and later earnings. Our estimated impacts on earnings alone are enough to fully recoup government expenditures within 10 years, suggesting that financial aid likely pays for itself several times over.

JEL Classification: H52, I22, I26
Keywords: Pell Grant

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1 Introduction

Federal and state governments provide substantial financial support to college students in the United States. During the 2015-16 academic year alone, low- and middle-income college students received $28 billion in federal Pell Grants, while state governments provided $10.5 billion in student grant aid (Baum et al. 2016). While some grant programs have been shown to increase attainment, most studies of Pell Grant aid find only small or no significant effects on enrollment or attainment. Furthermore, many studies have examined the effect of grant aid on student outcomes, but less is known about the social return to these expenditures.

In this study, we estimate effects of eligibility for additional grant aid provided to low-income college students on their contemporaneous and longer-run academic and labor market outcomes using administrative data from Texas public colleges and universities. Our empirical strategy exploits the Pell Grant formula in a fuzzy regression discontinuity design. Pell Grant aid is a weakly decreasing function of the student's expected family contribution (EFC), and only students with a $0 EFC qualify for the maximum Pell Grant. Students whose family income falls below a year-specific income threshold - ranging from $15,000 to $32,000 in adjusted gross income (AGI) - meet one of the main criteria for receipt of an "automatic zero EFC." In this setting, four-year college students with AGIs below the eligibility threshold are roughly 50 percentage points more likely to qualify for the maximum Pell Grant and receive approximately $700 more in total grant aid.

Eligibility for additional grant aid at college entry generates significant attainment and earnings gains for disadvantaged students near the automatic zero eligibility threshold. Among first-time bachelor's degree-seeking college students, qualifying for the maximum Pell Grant significantly increases graduation and earnings beginning four years and lasting at least seven years after entry - the duration of our panel. We provide evidence against potential confounds, such as selection into the sample or an increase in the likelihood of moving out of state, and show that our estimates are robust to a variety of specifications and sample selection criteria. Eligibility at entry also increases the total amount of grant aid received during college, an added social cost arising from behavioral responses and crowd-in of state grant aid. Nonetheless, effects on tax receipts are sufficiently large that the government should fully recover the increase in grant expenditures within ten years. Using the welfare framework of Denning et al. (2017), we predict that a budget-neutral increase in grant aid would be welfare enhancing.

Estimated effects of eligibility for additional grant aid among returning students are positive but largely insignificant. We find no significant effects on degree completion over any horizon, earnings gains are at most marginally significant, and estimated effects on cumulative earnings and tax payments are insignifi-

cant and half the size of the effects for students who gain eligibility at college entry.

Our data allow us to examine short- and medium-run effects of automatic zero EFC eligibility that provide evidence on the channels through which additional grant aid might increase attainment and earnings. Students who qualify for an automatic zero EFC at college entry are significantly more likely to receive a TEXAS Grant, a state grant program which generates a predictable stream of grant aid guaranteed to cover tuition and fees in future years. Eligibility leads first-time-in-college students to attempt more credits in the year of receipt and in each of the following two years, while returning students attempt significantly more credits in the year of eligibility but see no further attainment gains in future years. These patterns suggest that students benefit most when aid is received early enough to change their trajectory through college or when it leverages a longer, predictable commitment of generosity.

We also examine effects on community college students. In most settings, and among four-year college students in our sample, Pell Grant aid does not affect college enrollment or college quality (Kane 1995; Turner 2017; Carruthers and Welch 2015; Marx and Turner 2018; Denning (forthcoming)). In contrast, but consistent with Seftor and Turner (2002), we find that automatic zero eligibility is correlated with significant increases in the number of first-time-in-college and returning community college students, suggesting that additional grant aid affects enrollment decisions of individuals on the margin of attending a community college.

Our findings contribute to the broad literature examining the effects of college costs and financial assistance on student outcomes. Past research shows that prospective students' college enrollment decisions respond to changes in prices driven by variation in tuition and grant aid provided through simple, easily accessed programs (Deming and Dynarski 2010). In some settings, state grant aid shifts students into college, across different types of institutions, and into degree receipt (e.g. Scott-Clayton 2011; Castleman and Long 2016; Bettinger et al. 2016; Scott-Clayton and Zafar 2016). We contribute to this literature in several ways. We are the first to examine the within- and post-college earnings effects of the largest U.S. federal grant program. We exploit a novel source of variation that allows us to examine the effects of grant receipt on low-income students, which contrasts with previous studies that focus on variation in grant aid due to program phase-outs that target higher-income students. In work in progress, Matsudaira (2017) and Eng and Matsudaira (2018) study the same policy variation that we do, using enrollment and earnings data from federal tax records. We use administrative education and earnings records from a large state, which allows for estimates of how grant aid affects students' in-college finances and performance as well as degree completion and post-college earnings. Finally, we consider effects on tax receipts and provide implications for the social welfare effects of changes in grant generosity for programs targeting low-income students.

Our findings also have policy implications. While most studies find no significant effect of Pell Grant

aid on attainment, we find evidence of positive enrollment effects in community colleges and increases in four-year students' degree receipt. In particular, we find significant increases in graduation and earnings for first-time enrollees at four-year colleges. The strong effects for this group, and smaller, insignificant effects for returning students, provides evidence on features of aid programs that may enhance effectiveness. Receiving aid at entry may allow students to shift onto a new trajectory of study, and the crowd-in of state grant aid provides a stronger commitment of funding. The Pell Grant Program does not explicitly target students in their first year of college and does not guarantee a specific level of future funding, as a student's award is determined anew with each year's financial aid application. Researchers have proposed similar changes to the Pell Grant, so that a first-year student can plan for a known level of need that does not vary from year to year (e.g., Baum and Scott-Clayton 2013; Scott-Clayton 2017). Our results provide suggestive evidence that such restructuring could improve student outcomes. Results for first-time college students show that it is possible for increases in grant aid to offer a "free lunch," benefiting students to an extent that they more than repay the additional government spending.

The remainder of this paper proceeds as follows. In Sections 2 and 3 we describe the setting and data, respectively. We outline our empirical strategy in Section 4 and present the main results, robustness tests, and evidence on mechanisms in Section 5. In Section 6, we evaluate the welfare implications of increases in grant aid in our setting. Section 7 concludes.

2 Setting

In fall 2017, 37 Texas public four-year institutions served over 600,000 undergraduates, while 82 public community colleges enrolled more than 700,000 students (Texas Higher Education Coordinating Board 2018). Texas four-year public schools are largely representative of the average public four-year institution nationwide. In fall 2014, average annual in-state tuition was $7870 in Texas, while the national average for four-year public institutions was $8543 (National Center for Education Statistics 2016). The six-year graduation rate among four-year public school students in Texas was 53 percent, while the national average was 60 percent (Texas Higher Education Coordinating Board 2016). Texas public four-year schools range from selective research universities (e.g., University of Texas at Austin) to less selective, regional institutions.[1]

[1] In fall 2017, private colleges and universities in Texas enrolled over 125,000 undergraduates. Data on students in Texas private institutions are not available for research.

2.1 Federal student aid

Our identifying variation comes from a discontinuity generated by the federal need calculation that determines Pell Grant aid. A student's Pell Grant depends on the annual maximum and her EFC, which represents the federal government's estimate of the student and her family's ability to pay for college. All students must complete a free application for federal student aid (FAFSA) to qualify for Pell Grant aid. FAFSA inputs determine EFC through a complicated nonlinear formula that takes into account family income, assets, family size, siblings in college, and a host of other factors. A full-time, full-year student's Pell Grant is $Pell_{it} = \max\left\{\overline{Pell_t} - EFC_{it}, 0\right\}$. $\overline{Pell_t}$ is the maximum Pell Grant in year t and EFC_{it} is student i's expected family contribution. Only students who receive a \$0 EFC qualify for the maximum Pell Grant.[2]

Students with family AGI below a year-specific threshold meet one of the requirements to qualify for an automatic zero EFC. Only students with a \$0 EFC qualify for the maximum Pell Grant, but it is possible to receive a \$0 EFC without having income below the automatic zero threshold as EFC depends on other factors (e.g., family structure). In addition to meeting the AGI requirement, a student's parents must either have received means-tested benefits in the prior year or be eligible to file a 1040A or 1040EZ tax return (which generally excludes high asset families).

The automatic zero eligibility threshold varies over time. Prior to the 2006-07 academic year (hereafter 2007), the threshold was \$15,000. The cut-off increased to \$20,000 in 2007, \$30,000 in 2010, and \$31,000 in 2012, before falling to \$23,000 in 2013. Between 2014 and 2016, the threshold remained at \$24,000 and increased to \$25,000 in 2017. Online Appendix Figure B.1 displays the annual automatic zero EFC threshold and the maximum Pell Grant award. The latter increased from approximately \$4000 to approximately \$6000 (in nominal terms) over the period we examine.

Students who complete a FAFSA are also eligible for federal loans. Federal loans made up approximately 90 percent of loan disbursements to undergraduate students in recent years (Baum et al. 2016). Federal subsidized loans do not accrue interest while a student is enrolled in at least 6 credits per semester and are available to students with unmet need (equal to the total cost of attendance less EFC and grant aid from all sources). Students may borrow subsidized loans up to the lesser of the subsidized loan maximum (e.g., \$3500 for first year, dependent students) and unmet need. Subsidized loan eligibility could be affected by receipt of an automatic zero EFC, but unsubsidized loans are available to almost all FAFSA filers regardless of financial need, and federal loans have yearly and lifetime borrowing limits that do not vary with

[2]Part-year students receive a prorated Pell Grant. Students with less than full-time enrollment are eligible for a lower maximum Pell with a flatter phase-out. Awards are rounded to nearest \$100. In a small number of cases when students face a sufficiently low cost of attendance (which includes tuition, fees, room and board, and other expenses), Pell Grants may be reduced so as not to exceed total unmet need.

need or family income.[3]

Private student loans may be available to students who have exhausted their eligibility for federal loans. However, private loans entail a credit-worthiness requirement and/or require a cosigner and generally carry higher interest rates than federal loans. Nationwide, only 6 percent of undergraduate students with family AGIs near the automatic zero EFC eligibility threshold received private loans, while 28 percent stated that they would have borrowed more if funds were available, suggesting few undergraduates can access loans that are not publicly provided (authors' calculations using the 2012 NPSAS via PowerStats).

2.2 Texas financial aid programs

Texas' largest financial aid program is the TEXAS (Towards EXcellence, Access and Success) Grant. TEXAS Grant disbursements equaled $200 million in 2008. The maximum TEXAS Grant award for bachelor's degree seeking students in four-year public institutions equals the statewide average of tuition and required fees within the four-year public sector and the maximum amount available to community college students is similarly the statewide average of tuition and required fees across all community colleges. Eligibility for a TEXAS Grant is based on family income and financial need at college entry.[4] The program is oversubscribed; approximately 50 percent of eligible students do not receive a TEXAS Grant (Cohen et al. 2010). Schools have discretion over which students receive a TEXAS Grant and must use institutional funds to cover remaining tuition and fees after federal and TEXAS Grant aid is applied, which may provide an incentive for institutions to give TEXAS Grants to students eligible for large amounts of other grant aid. Smaller Texas grant and loan programs are described in Online Appendix A.

3 Data and Sample

Our data come from the Texas Higher Education Coordinating Board (THECB) and Texas Workforce Commission (TWC). The THECB collects administrative data from all public institutions in Texas, including student-level information on enrollment, graduation, college major, GPA, credits attempted, a subset of FAFSA inputs (including AGI), EFC, and financial aid disbursements. TWC data contain quarterly earn-

[3]Unsubsidized loans have weakly-higher interest rates than subsidized loans and start accruing interest at disbursement. Online Appendix A provides additional information on federal loan options. Our main results are robust to limiting the sample to the subset of students whose eligibility for loan aid is not affected by automatic zero EFC eligibility.

[4]TEXAS Grant recipients must have financial need and enter public higher education within 16 months of graduating from a Recommended High School Program. Alternatively, students may qualify if they enter a public four-year institution no more than 12 months after receiving an associate's degree from a public two-year institution in Texas. Additionally, students' EFCs must fall below a year-specific threshold - approximately $4000 in the period we examine. To maintain eligibility, recipients must earn at least a 2.5 GPA, complete at least 24 credit hours in an academic year, and not receive grants in excess of their cost of attendance (http://www.collegeforalltexans.com/apps/financialaid/tofa2.cfm?ID=458).

ings records for all employees in industries covered by unemployment insurance (UI) in Texas.[5] We base our measure of annual earnings on the academic year rather than calendar year and winsorize earnings at the 99 percentile. For year t, academic year earnings equal the sum of quarterly earnings from the 4th quarter of year $t-1$ through the third quarter of year t. We winsorize earnings to deal with a small number of outliers in the earnings data. All earnings and financial aid awards are adjusted for inflation using the CPI-U to represent constant 2013 dollars.

Our primary analysis sample includes first-time-in-college (hereafter, "FTIC") and returning students who enrolled in a public four-year institution in Texas in the 2008 through 2011 academic years, although we perform a limited number of supplemental analyses for community college students who enrolled over this same period.[6] This time horizon includes the first cohort for which parent AGI is available (2008) and allows us to track students for up to seven years. We observe five years of outcomes for all students in the sample, six years for students entering or returning in 2008 through 2010, and seven years for the 2008 and 2009 cohorts. We focus on students with family AGIs within $12,000 of the automatic zero EFC income eligibility threshold; this is approximately equal to the median Imbens and Kalyanaraman (2012) optimal bandwidth across the outcomes of interest. We show that our results for FTIC students are robust to using smaller or larger bandwidths. Estimated effects for returning students, which are generally smaller, are less robust to larger bandwidths.[7] We limit our sample to students classified as dependent, as most independent students are ineligible for an automatic zero EFC, irrespective of AGI.[8] We observe "heaping" at $1000 intervals in AGI (Online Appendix Figure B.2). Because regression discontinuity estimates may be biased with non-random heaping at specific values of the running variable (Barreca et al. 2016), and because the cutoff for the automatic zero EFC occurs at a multiple of $1000 in all years, our preferred specification excludes students who report EFCs at multiples of $1000.[9] Estimates for FTIC students are robust to the inclusion of these observations. Our final sample includes 37,227 FTIC students and 110,607 returning

[5]UI records cover employers who pay at least $1500 in gross wages to employees or have at least one employee during twenty different weeks in a calendar year. Students employed by their college or university are not included.

[6]A small number of students enroll in both community colleges and four-year institutions. Students who are observed with any four-year enrollment in the baseline year are classified as four-year students. Analysis of the community college sector therefore exclude students who enroll in four-year institutions during the baseline year. As Section 4.1 discusses, because we find evidence of a significant enrollment response among community college students, we cannot obtain unbiased estimates of the effect of automatic zero eligibility on academic and labor market outcomes and thus limit our focus to enrollment effects. Characteristics for the community college analysis sample are included in Online Appendix Table C.1.

[7]AGI is only observed for FAFSA-filers, thus non-filers are automatically excluded. Among 2012 dependent students entering public four-year institutions with AGIs within $12,000 of the automatic zero threshold, 89 percent of FTIC students and 87 percent of returning filed a FAFSA (2012 NPSAS, authors' calculations via PowerStats).

[8]Only independent students with dependents are eligible for an automatic zero EFC. Other independent students (those who are 24 or older and/or married) do not qualify. Nationwide, only 3.6 percent of undergraduates entering public four-year institutions had dependents and among returning four-year public students, 16 percent had dependents (authors' calculations using the 2012/14 Beginning Postsecondary Students (BPS) study and 2012 National Postsecondary Student Aid Study (NPSAS) via PowerStats).

[9]Our AGI measure comes from administrative FAFSA data reported to the THECB. One explanation for the heaping is that students are allowed to submit their FAFSA before their parents have filed their taxes and report an estimated AGI (that will later be updated with a revised submission). Our data only contain information from one FAFSA (not necessarily the final version). Online Appendix Table B.1 compares the characteristics of heapers and nonheapers who are FTIC college entrants. Heapers are less likely to be Texas residents, less likely to be white, and more likely to have college educated parents.

students.

Table 1 displays sample characteristics of FTIC and returning students. Characteristics are largely similar to those of bachelor's degree seeking dependent public college entrants and returning students nationwide in 2008 (Online Appendix Table B.2). On average, FTIC students are 19 years old at entry, and 97 percent are Texas residents. Returning students, who are within two through six years of entry, are approximately 21 years old on average, and 98 percent are Texas residents.

Racial/ethnic minorities comprise a substantial share of the sample, with 45 percent of both FTIC and returning students identifying as Black or Hispanic. Most students do not have parents who attended college: less than 30 percent report having a father or having a mother with a college degree. FTIC students receive a substantial amount of grant aid - over $9500 - in their first year of enrollment. Returning students receive less but still sizable amounts of grant aid averaging $7600. FTIC students borrow less than returning students (approximately $2700 versus $4040) and have lower earnings ($3803 versus $7412) at baseline. Sample members come from relatively low-income families, especially compared to students near the eligibility threshold for grant aid programs that are commonly studied.[10] Both FTIC and returning students with AGIs below the automatic zero EFC threshold receive more grant aid, take on less student loan debt, and earn less than do students above the threshold.

4 Identification Strategy

For identification, we exploit the nonlinear relationship between AGI and automatic zero EFC eligibility, which in turn, generates a discontinuous increase in the grant aid. Let agi_t^0 represent the value of the automatic zero EFC cutoff in year t. For student i belonging to cohort t, $\widetilde{AGI}_{it} = AGI_{it} - agi_t^0$ is the distance her family's income falls from the year-specific threshold. When a student is ineligible for an automatic zero, her EFC is determined by a complicated nonlinear function of family income, assets, and many other characteristics that are both observable ($\mathbf{X_i}$) and unobservable (U_{it}):

$$EFC_{it} = \mathbf{1}\left(\widetilde{AGI}_{it} > 0\right) \times f\left(AGI_{it}, \mathbf{X_i}, U_{it}\right).$$

[10] Carruthers and Welch (2015) and Marx and Turner (2018) examine the cutoff for the minimum Pell Grant (roughly $50,000 in family AGI). Castleman and Long (2016) examine a change in Florida state grant aid for students with an EFC of $1590 corresponding to an income of $40,000 (in 2011$). Eligibility for the Cal Grant studied by Bettinger et al. (2016) involves both income and high school GPA thresholds, with the former corresponding to approximately $60,000 in family income and the latter affecting aid receipt for students from higher income families.

We quantify the effect of automatic zero EFC eligibility via ordinary least squares (OLS):

$$Y_{it} = \beta \mathbf{1}\left(\widetilde{AGI}_{it} > 0\right) + f\left(\widetilde{AGI}_{it}\right) + \mathbf{X_i}\boldsymbol{\gamma} + \delta_t + \epsilon_{it} \tag{1}$$

where Y_{it} represents the outcome of student i belonging to cohort t, $\mathbf{1}\left(\widetilde{AGI}_{it} > 0\right)$ indicates automatic zero EFC eligibility, $f\left(\widetilde{AGI}_{it}\right)$ is a function of normalized AGI (allowed to vary on either side of the eligibility threshold), $\mathbf{X_i}$ is a vector of observable student characteristics (indicators for parental education, race, gender, and Texas residency, and a continuous term in age at entry), and δ_t is a set of entry-cohort fixed effects. Under the identifying assumption that, in the neighborhood of the eligibility threshold, all unobservable factors that are correlated with both Y and \$0 EFC receipt are continuous through the threshold, $\hat{\beta}$ represents the causal effect of automatic zero eligibility on student outcomes (Hahn et al. 2001).

In practice, we estimate local linear regression models with a uniform kernel and bandwidth of \$12,000 (approximately the median of the optimal bandwidths across outcomes chosen by the Imbens and Kalyanaraman (2012) procedure). We also show that our main estimates are robust to larger and smaller bandwidths and to controlling for a quadratic function of $\widetilde{AGI}$. Standard errors are clustered at the cohort by institution level to account for correlated outcomes within cohort-institution groups.

Assuming that eligibility for an automatic zero EFC only directly affects student outcomes by increasing grant aid allows for instrumental variables (IV) estimates of the effect of additional grant aid on attainment; $\mathbf{1}\left(\widetilde{AGI}_{it} > 0\right)$ serves as the excluded instrument. As long as eligibility weakly increases grant aid for all students, IV estimates represent the weighted average of causal responses to a marginal increase in grants on student outcomes for the set of students induced to receive a \$0 EFC by meeting the AGI eligibility requirement (Angrist and Imbens 1995). To facilitate comparisons between the effects we find and estimates of the effects of other grant programs, we scale treatment effects by the change in first-year grant aid.

4.1 Evaluating the RDD identifying assumptions

Our key identifying assumption requires that students and their families not be able to perfectly control their AGIs to obtain an automatic zero EFC. Though income may be under-reported generally, in recent years, over half of all Pell Grant eligible students were selected for FAFSA verification, and income is one of the main components that is audited. General under-reporting will not threaten identification unless students and their families are more likely to under-report when their income falls just above the threshold, which is unlikely, as the existence of this cutoff is not well known or publicized, and the threshold varies substantially from year to year. A second potential concern in our particular setting is the possibility that students' enrollment decisions respond the change in EFC (or corresponding change in grant aid). We will

be able to capture and account for the effects of such responses to the extent that they occur within public institutions in Texas. However, if students are induced to switch from an out-of-state or private institution, we will not be able to obtain unbiased estimates of the effect of automatic zero eligibility without stronger assumptions about the nature of selection.

Although our key identifying assumption is fundamentally untestable, it generates the testable predictions of continuity in the density of $\widetilde{AGI}$ and continuity in the distribution of predetermined characteristics at the automatic zero eligibility threshold (Lee and Lemieux 2010). We test for such discontinuities and present graphical evidence and formal estimates for four separate groups: FTIC and returning students within community colleges and four-year institutions.

Figure 1 displays the density of $\widetilde{AGI}$ by plotting the number of students in \$1000 AGI bins on either side of the eligibility threshold. Dark solid lines represent local linear regressions of the number of students on distance from the automatic zero eligibility threshold within a \$9000 bandwidth, estimated separately for eligible and ineligible students. Lighter dashed lines are corresponding 95 percent confidence intervals.[11] For both FTIC and returning four-year students, there is no observable or statistically significant change in the number of students across the automatic zero EFC eligibility threshold. Among FTIC four-year students, the lack of a significant discontinuity is robust to varying the bandwidth and bin size. Among returning four-year students, however, we obtain marginally significant estimates when using larger bandwidths and smaller bin sizes that suggest an approximately 3 percent increase in enrollment of eligible students relative to those with AGIs above the threshold (Online Appendix Table B.3). If there are positive enrollment effects for returning four year students, estimates of long term outcomes may be biased because marginal enrollees could have different, unobserved characteristics that affect longer term outcomes.

To further explore the possibility of enrollment responses, we test for discontinuities in predetermined student characteristics. To generate a single index of covariates, we predict the probability of graduating within four years of college entry via a logistic regression on all predetermined covariates. We find no evidence of a statistically significant change in the predicted probability of four-year graduation, with 95 percent confidence intervals excluding effects larger than a 0.1 percentage point difference for both FTIC and returning students.[12]

[11] For the purpose of presentation, we have chosen a bandwidth that falls between the IK-optimal bandwidths of approximately \$6000 for estimating effects on the number of enrolled students and approximately \$12,000 for other outcomes. Varying the bandwidth does not change the statistical significance of any of the results, but the curvature in the density around \$10,000 to the left of the threshold leads to larger point estimates when using a linear estimator over larger bandwidths.

[12] As shown in Online Appendix Table B.4, eligible FTIC four-year students are 1.2 percentage points (9 percent) significantly more likely to be have a father with less than a high school education ($p < 0.1$) and 2 percentage points (4 percent) less likely to have a high school educated father ($p < 0.1$). Appendix Table B.5 shows that returning students are 2 percentage points less likely to be black ($p < 0.1$) and 0.6 percentage points more likely to be classified as in-state ($p < 0.05$). Estimates are slightly smaller (1.6 percentage points and 0.5 percentage points, respectively) but remain still statistically significant when using the IK-optimal bandwidths (\$7490 and \$12,060, respectively). Eligible returning students are also 0.9 (1.4) percentage points more likely to have fathers (mothers) with less than a high school degree, 2 percentage points less likely to have mothers with a high school degree, and 0.7 percentage points less

Finally, we estimate effects of automatic-zero eligibility on measures of institutional quality to test whether eligibility for additional grant aid leads to upgrading to more selective or higher quality institutions. We examine effects on inputs (e.g., characteristics of the student body, selectivity), resources (e.g., costs, expenditures, student-faculty ratios), and outputs (e.g, retention and graduation rates). All measures of institutional quality come from the Integrated Postsecondary Education Data System (IPEDS). To create a summary of the numerous measures of institutional quality and to deal with concerns of spurious significant estimates due to the number of hypotheses being tested, we examine effects on the first component from a principal component analysis of these quality measures (Black and Smith 2006). As shown in Online Appendix Tables B.6 and B.7, we find no statistically significant effects of eligibility on any of the institutional quality measures beyond a 0.9 percentage point (2 percent) increase in the average admissions yield of institutions attended by newly entering eligible students ($p < 0.1$), a \$36 (1 percent) reduction in tuition and fees charged by institutions attended by returning students ($p < 0.1$), and a \$93 (0.5 percent) reduction in institutional expenditures on instruction per full-time-equivalent (FTE) student for institutions attended by returning students ($p < 0.1$). Estimated effects on the first principle component (FPC) are small and statistically insignificant for both FTIC and returning four-year students. The mean difference between consecutively ranked Texas public four-year institutions is 0.47, over three times larger than the increase in quality (as measured by the FPC) for FTIC students, and over eight times larger than the increase in quality of institutions attended by returning students.

In contrast to the four-year sector, we find consistent evidence of a significant enrollment response to automatic zero EFC eligibility among community college students. Panels C and D of Figure 1 show a visible discontinuity in the density of both FTIC and returning community college students. Eligibility increases enrollment of first-time community college students by 7 to 10 percent and enrollment of returning students by 3 to 8 percent (Online Appendix Table C.2), effects that are statistically significant for almost every bandwidth and bin size. Our finding of enrollment responses in only this sector is consistent with the fact that only a few papers in the literature have found evidence that Pell Grant aid increases enrollment and these effects are largely limited to non-traditional students.

Enrollment effects limit our ability to make further causal inference about effects for community college students because the treatment group also includes marginal students who were induced to join the sample. Tests of the continuity of predetermined covariates do not provide evidence of consistently positive or negative selection into the sample (Online Appendix Tables C.3 and C.4), limiting our ability to sign the effects of selection bias. Estimated correlations between eligibility and measures of institutional quality

likely to have a missing maternal education level. These effects shrink in magnitude but remain significant when using the (generally smaller) IK-optimal bandwidths.

are all negative but small in magnitude and largely insignificant at conventional levels (Online Appendix Tables C.5 and C.6).

While the enrollment response of community college students additional Pell Grant aid complicates estimation of the effects of automatic zero EFC eligibility on most of the outcomes we examine, an enrollment response also represents a potential benefit of eligibility for additional grant aid. Some of the marginal community college students may have otherwise enrolled in and graduated from other colleges, but the lack of an enrollment or upgrading response in the public four-year sector suggests that such responses are likely limited to students who would have attended private colleges or left the state. We highlight this suggestive result as an opportunity for future research using alternative data sets that include applicants and a larger set of institutions. We include RD estimates for this sector in Online Appendix C for completeness and, hereafter, focus on four-year students.

4.2 Graphical evidence of first stage and effects on financial aid

Figure 2 displays the relationship between $\widetilde{AGI}$ and \$0 EFC receipt for FTIC and returning four-year students. Some students who are income-eligible (hereafter, "eligible") for an automatic zero are disqualified based on other requirements (in most cases, related to family assets and non-earned income). Likewise, students who are ineligible for an automatic zero EFC based on AGI may still qualify based on other FAFSA inputs. Thus, income eligibility (hereafter, "eligibility") imperfectly predicts receipt of a \$0 EFC. However, both FTIC and returning students are approximately 50 percentage points more likely to receive a \$0 EFC when their AGIs fall below the eligibility threshold.

Students with a \$0 EFC qualify for the maximum Pell Grant. No other federal grants are explicitly linked to a \$0 EFC, but many federal and state programs target students with high levels of unmet need (see Online Appendix A). Eligibility generates an approximately \$700 increase in total grant aid (Figure 3, Panel A), driven by an approximately \$500 increase in Pell Grant aid (Panel B). Eligible FTIC students also experience a smaller discontinuous increase in TEXAS Grant aid, which contrasts with the lack of a visible effect (and generally lower levels of TEXAS Grant aid) for returning students (Panel C). Average grant aid from other sources is continuous through the eligibility threshold for both groups (Panel D), as is work-study (Panel E), while the level of student loans decreases discontinuously (Panel F). While the relationship between eligibility and Pell Grant aid is purely mechanical, the relationships in Panels C, D, and E may involve both mechanical effects due to state policies and the endogenous response of institutions to changes in a given student's EFC and financial aid package, and the relationship in Panel F is generated by endogenous responses of students.

5 Empirical Results

We preview our key findings with graphical evidence of the reduced form relationship between $\widetilde{AGI}$ and student outcomes for FTIC students. Corresponding figures for returning students - which display similar contemporaneous effects and smaller long-run effects - are included as noted in Online Appendix B. Eligibility for an automatic zero EFC at entry has only negligible effects on credit hours attempted, GPA, earnings, or the probability of reenrollment in the following year (Figure 4 and Appendix Figure B.3). Over the longer-run, eligibility increases the probability of graduation for FTIC students starting four years after entry (Figures 5). Increases in graduation rates persist for the duration of our panel, up to 7 years after college entry. Likewise, eligibility appears to generate earnings increases for FTIC students four years after entry, and these gains persist for the remainder of our panel (Figure 6). In contrast, eligibility does not appear to increase graduation rates or earnings of returning students (Appendix Figures B.4 and B.5).

Summing across all years in which we observe sample members, we calculate total grants, loans and earnings. Automatic-zero eligibility at entry is correlated with discrete increases in total grant aid received and total earnings (Figure 7). Effects on total earnings for returning students are also positive but smaller in magnitude. Despite the reduction in borrowing shown in Figure 3, automatic zero eligibility at entry does not appear to change cumulative debt by the end of our panel.

5.1 Short-run effects on finances and academics

Although endogenous decisions by students and institutions may diminish changes to cash on hand generated by automatic zero EFC eligibility, in our setting, the significant increase in Pell Grant aid – \$489 for FTIC students and \$659 for returning students – crowds-in grant aid provided through the TEXAS Grant program for FTIC students (\$151) and grant aid from other sources for returning students (\$99) (Table 2). Eligibility does not significantly affect contemporaneous earnings, has only small effects on work-study aid, but leads to a statistically significant reduction in the amount borrowed equal to \$343 for FTIC students and \$225 for returning students.

Effects on contemporaneous academic outcomes are relatively small. Eligibility leads to small increases in credits attempted by FTIC and returning students (0.26 and 0.22, respectively), a 1 percentage point increase in returning students' probability of reenrolling in the following academic year, and does not significantly affect GPAs of students in either group (Table 3). Estimated 95-percent confidence intervals exclude increase greater than 0.5 credits attempted (2 percent), a 2 percentage point (3 to 4 percent) increase in returning the following academic year, and a 0.08 (4 percent) GPA increase.

5.2 Longer-run effects on attainment, earnings, and tax payments

We next examine effects on longer-run academic outcomes including reenrollment, credits attempted, and degree receipt. Panels A through C of Figure 8 display point estimates and corresponding 95 percent confidence intervals from equation (1), which represent reduced-form effects of automatic zero EFC eligibility, by the number of years since the base year in which a student's AGI falls within the $12,000 bandwidth.[13] We find no effects on enrollment within Texas public four-year institutions that are significant at the 5 percent level (Panel A), although point estimates are positive in the first four years.[14] In addition to the marginally significant increase in first-year credits attempted ($p < 0.1$), eligibility at entry significantly increases FTIC students' credits attempted by 0.6 one year later and 0.7 two years later (Panel B). Effects on returning students' credits attempted are significant in the following year but not two years later, and they are about half the size of FTIC students' gains.

Automatic zero eligibility at entry significantly increases FTIC students' probability of graduation within four, five, and six years of entry (Figure 8, Panel C). Eligible students are approximately 1.5 percentage points more likely to earn a bachelor's degree within four years (a 10 percent increase relative to the mean completion rate for barely-ineligible students) and 3.3 percentage points more likely to graduate within five and six years of entry (representing 11 and 8 percent increases, respectively). The estimated impact on FTIC students' probability of graduation within seven years is significant at the 10 percent level and similar in magnitude to estimated effects on the five- and six-year horizons, but because we only observe two entry cohorts for this length of time, the estimate is less precise. In contrast, eligibility has no effect on graduation rates of returning students at any future point, and estimated effects are less than a third of the size of effects for FTIC students.

The contrast between small contemporaneous attainment gains and relatively large increases in graduation for students who qualify for an automatic zero EFC at entry is perhaps surprising. Gains could be larger in years after receipt if the aid puts the student on a new trajectory of study (e.g., if small initial gains increase students' confidence or if the experience in the year of receipt and the resources that remain after it affect subsequent decisions). We discuss this possibility in Section 5.4, along with the persistence in FTIC students' eligibility for TEXAS Grant aid, as plausible explanations for the patterns we find and the differences in attainment effects of automatic zero eligibility between FTIC and returning students.

In the longer-run, increases in graduation rates for FTIC students might persist (as in Bettinger et al.

[13] For any given horizon, estimates include both enrolled students and those who have completed or left college.

[14] As shown in Table 3, the estimated 1 percentage point increase in the reenrollment probability of returning students one year later is significant at the 10 percent level. The 2.2 percentage point increase in FTIC student's enrollment three years after entry is significant at the 10 percent level. We find no evidence of significant impacts on the probability of transferring to a Texas community college for FTIC or returning four-year students (Online Appendix Figure B.6).

2016) or fade (as in Scott-Clayton and Zafar 2016). Approximately 7 percent of ineligible students and 8 percent of eligible students are still enrolled 7 years after entry. To close the gap in the overall graduation rate, the difference in the probability of graduation between eligible and ineligible FTIC students still enrolled 7 years after entry would have to exceed 50 percentage points (e.g., 100 percent of still-enrolled ineligible students and less than 45 percent of still-enrolled eligible students would eventually graduate). Thus, while there is scope for the the impacts on graduation to ultimately represent retiming of degree receipt rather than increases in new graduates, ineligible students' outcomes would need to dramatically improve for the gains in degree receipt to disappear.

Next, we examine effects on annual earnings (Figure 8, Panel D). Automatic zero eligibility at college entry results in significant earnings gains beginning four years later and lasting through the end of our panel.[15] Earnings gains could theoretically increase or decrease over time, depending on the timing of returns to a bachelor's degree receipt and the extent to which ineligible students' degree receipt converges with that of eligible students. Complete convergence in the graduation rates of eligible and ineligible students is unlikely. Given evidence that estimated returns to education are decreasing in time-to-degree, the estimated earnings gains will most likely persist over the long-run (Flores-Lagunes and Light 2010). Estimated earnings effects are smaller for returning students. Effects on earnings are marginally significant between three years and five years after qualifying for an automatic zero. Despite the difference in magnitude of estimated effects of automatic zero eligibility on FTIC versus returning students' earnings, we cannot reject a test of their equality.

To facilitate a comparison of our estimates with those found in other settings, we scale the reduced form effects on attainment and earnings outcomes by the increases in baseline grant aid. We estimate instrumental variables (IV) models in which the indicator for income below the eligibility cutoff serves as the excluded instrument. For each $1000 of grant aid received at college entry, the probability of graduating within five years later increases by about 5 percentage points, around 15 percent relative to mean completion rates of ineligible students (Table 4). We find similar effects of grant aid on graduation within six and seven years of entry. Estimated effects of additional grant aid on returning students' graduation rates are small and insignificant. Five years after aid receipt, we can rule out effects larger than a 2 percentage point (2.4 percent) increase. For FTIC students, a $1000 increase in grant aid is associated with later-year earnings increases of more than $1000 beginning four years after entry (Table 5).[16] In contrast, estimates for returning students

[15]We find no evidence that automatic zero eligibility affected the probability of having nonzero earnings (Appendix Table B.8). Estimated impacts on earnings are quite similar when we use non-winsorized earnings except at 7 years post-entry, when a very small number of FTIC students had a very large amount of earnings (Online Appendix Table B.9).

[16]The impacts of additional grant aid at entry we estimate are comparable to the effects of increased grant aid found by Bettinger et al. (2016). Mean outcomes for ineligible students at the Cal Grant GPA eligibility threshold studied by Bettinger et al. (2016) are similar to those in our setting. The change in total grant aid at the eligibility threshold is about $4000, roughly three times the magnitude of the increase in grant aid at the automatic zero EFC threshold. Estimated effects of initial eligibility on degree receipt are roughly

are roughly half as large and only significant three and five years after aid receipt.

Finally, we examine effects on estimated federal income and payroll taxes. We use data from the American Community Survey (ACS) covering 2006 through 2016 to translate estimated impacts on earnings into effects on federal and FICA tax receipts. Specifically, we use data on income, marital status, children, mortgage payments, and property taxes with NBER's TAXSIM to estimate marginal federal income tax rates for 18 through 31 year olds who are either currently enrolled in college or had attended college in the past.[17] We calculate average marginal income tax rates and average inflation-adjusted earnings (the measure of income that is observed within the Texas data) for the age(s) that students are expected to be after a given number of years since qualifying for an automatic zero EFC. For example, we assume that in the base year, FTIC students are 18 years old and returning students are 19-24. We calculate average marginal rates for individuals in $10,000 earnings intervals (e.g., $1,000 to $11,000, $2,000 to $12,000, etc.) and use the rate corresponding to the interval with average earnings that is closest to the right-hand-side limit of earnings at the automatic zero EFC threshold ("mean | ineligible" in Table 5). We assume that eligible students' additional earnings would be subject to this marginal rate, and scale effects on earnings (shown in Figure 8) by this rate to estimate the additional federal income tax payments that would be generated. We do the same for FICA taxes, which have average and marginal rates that are essentially the same for all ages and income intervals over these years, at 14.9 percent (taking into account both employee and employer contributions).[18] Online Appendix D provides additional details.

Figure 9 plots the estimated effects of baseline automatic zero eligibility on later-year tax payments. Corresponding to the significant increases in earnings starting four-years after college entry, we predict that eligible FTIC students will make significantly larger income and payroll tax payments over this same time horizon. Effects on returning students' federal income and payroll taxes are smaller and largely insignificant.

5.3 Robustness of estimates

Interpretation of estimated impacts on earnings is complicated by the fact that we only observe earnings for jobs covered by the Texas UI system. If someone does not work, moves out of state to work, or works in a non-covered job, they will appear to have no earnings. Automatic zero EFC eligibility could affect the

proportional: Bettinger et al. (2016) find increases in bachelor's degree receipt that are twice as large as the effects in our setting, and impacts on log labor income due to Cal Grant eligibility translates to a $1630 increase in annual earnings, about 1.5 larger than the effect on annual earnings from automatic zero EFC eligibility five and six years after entry.

[17] The ACS contains most, but not all of the inputs TAXSIM requires to calculate tax liabilities and rates (earned income, investment income, retirement and SSI benefits, and cash welfare are observed; short- and long-term capital gains/losses, other property income, and UI benefits are not observed). See Feenberg and Coutts (1993) for a description of TAXSIM.

[18] This rate is below the current statutory payroll tax contribution because our panel includes 2011 and 2012, when the employee portion of the Social Security tax was lowered from 6.2 to 4.2 percent.

probability that a student remains in state (or in a UI-covered job).[19] In this case, estimated earnings gains will not represent the causal effect of eligibility for additional grant aid. To address this concern, we test whether eligibility affects the probability of being observed "in state," defined as either having earnings or enrollment in a public institution. Eligibility does not significantly alter the probability of being in state. Point estimates only exceed a 1 percentage-point increase at the seven-year horizon, when the underlying sample is smallest (Online Appendix Figure B.7).

We estimate bounds on eligible students' earnings gains, following Lee (2009). Specifically, we "trim" the earnings of automatic zero EFC eligible FTIC students at the top of the distribution of observed earnings by setting these students' earnings to \$0. We use the years-since-entry-specific estimated change in the probability of remaining "in-state" shown in Online Appendix Figure B.7 to determine the share of eligible students to trim. This exercise produces bounds under the extreme assumption that the entirety of the (insignificant) difference in the probability of being in-state comes from eligible students with the highest earnings who would have otherwise left Texas (rather than, for instance, an increase in the probability of employment). The estimated lower bounds on FTIC students' earnings gains four to seven years after entry average to approximately 40 percent of the effect size produced by our main specification. If the lower bound of estimated earnings gains for eligible students seven years after entry (\$586) persists over a 35-year career, the lifetime earnings effect would be roughly 30 times the size of the initial grant.

Our findings for FTIC students are robust to several alternative specifications (Online Appendix Table B.10). Models that exclude predetermined student covariates are quite similar to those produced using equation (1) (Panel A). Likewise, including students "heaping" at AGI multiples of \$1000 does not alter our findings (Panel B). Our results are not substantially affected by reducing the bandwidth to \$6000 (Panel C) or increasing it to \$18,000 (Panel D). Finally, Panel E shows that estimates from models that use a bandwidth of \$18,000 and a quadratic in $\widetilde{AGI}$ are quite similar to those produced by our preferred specification. In contrast, the positive, significant effects of eligibility on returning students' earnings in some years are less robust to the inclusion of "heapers" and to the larger bandwidth (Online Appendix Table B.11).

Finally, we address concerns that increases in financial aid driven by automatic zero EFC eligibility can reduce some students' federal loan eligibility.[20] To the extent that such students would borrow more if

[19]College educated young adults are more likely to move between states than those with less education (Malamud and Wozniak 2012). Andrews et al. (2016) rule out systematic differences in earnings for students who leave Texas and those who remain. Furthermore, young college educated adults are relatively unlikely to move out of Texas. Using the IPUMS-CPS (Flood et al. 2015), we estimate an annual interstate migration rate of 3.2 percent for young adults (20-24 years old) with some college in Texas between 2010 and 2016. State grant aid eligibility may also have small effects on interstate migration (e.g., Fitzpatrick and Jones 2016; Bettinger et al. 2016) but it is not clear whether these findings can be generalized to the effects of federal grant aid on the probability remaining in state after attending college.

[20]Students are allowed to borrow up to their cost of attendance (COA) less total grant aid. A student's COA equals tuition and fees, books and supplies, and estimated living and transportation expenses. If qualifying for an automatic zero reduced a student's remaining need (COA - total grant aid) to below the maximum available federal loan, the amount she could borrow would be mechanically reduced. See Online Appendix A for additional details. To determine which students would not have their loan eligibility affected by

they were ineligible for an automatic zero EFC, our estimates would represent the reduced form effects of both the additional grant aid that automatic zero eligibility generates and the conversion of loans to grants. Thus, we present a subset of our results for the subsample of FTIC students who should qualify for the maximum federal loan whether or not they receive an automatic zero EFC; results for returning students are similar. Estimated effects on academic outcomes and earnings are quite similar in the restricted sample (Online Appendix Table B.12).

5.4 Mechanisms

Our findings thus far show that receiving an automatic zero EFC and the corresponding increase in grant aid significantly increases attainment and earnings, but only for FTIC students. In this section, we explore potential mechanisms through which eligibility could generate these effects and explanations for why additional grant aid may be especially effective when provided to entering students.

Given the extensive evidence of earnings gains from bachelor's degree receipt (e.g., Barrow and Malamud 2015), and our finding of significant increases in degree completion among eligible FTIC (but not returning) students, a substantial portion of the effects on FTIC students' earnings is likely driven by their increased graduation rates. Zimmerman (2014) studies an admissions threshold for a four-year institution and finds receipt of a bachelor's degree is associated with an annual earnings increase of about $30,000 (in 2005$). For FTIC students at four-year colleges, when we scale our estimated earnings effects by our estimated effects on graduation, we find an average increase of $32,000 (in 2013$), providing suggestive evidence that graduation effects can explain much of the increase in earnings. However, other factors may also play a role. In theory, grant aid could affect the level of student loan debt, which could then alter the likelihood that a student later chooses a high-paying job (Rothstein and Rouse 2011). However, we find limited evidence of the effect of student loan debt at the end of our panel (Figure 7). Second, eligibility for additional grant aid could induce students, especially those who are early in their college careers, to choose more time-intensive but higher-paying majors. Eligibility has small but statistically significant effects on the probability that FTIC students declare a science, technology, engineering, or math (STEM) major (available upon request). However, these effects are sufficiently small that most likely only explain a small share of estimated earnings gains relative to the effects of degree receipt.

Having found little evidence for other channels through which an automatic zero EFC could affect earnings outside increased degree completion, we next explore possible explanations for the significant ef-

automatic zero eligibility, we add any TEXAS Grants received by a student to unmet need (cost of attendance - EFC - grants) to determine the unmet need a student would have in the absence of any TEXAS Grant. We then limit the sample to students for whom this amount exceeds $13,500, i.e. those whose true unmet need would still exceed the $5500 (as required to borrow the maximum federal Direct Loan) even if the additional Pell Grant aid were to crowd in $8000 of TEXAS Grant aid (the 99th percentile in the sample).

fects of eligibility on FTIC students' graduation rates and the lack of similar effects for eligible returning students. First, prospective students could be induced to upgrade to institutions that produce higher graduation rates (Cohodes and Goodman 2014). However, as discussed in Section 5, we do not find evidence of such upgrading and can rule out all but small effects of automatic zero eligibility on observable measures of institutional quality. More generally, early receipt of funding could shift students to a more successful academic trajectory. As was seen in Panel B of Figure 8, the number of credits attempted by FTIC students significantly increases one and two years after grant receipt, whereas the effect for returning students one year later is only marginally significant, despite smaller standard errors. These dynamic effects appear to differ despite similar baseline effects on grant aid, loans, work study, and credits attempted (Tables 2 and 3).[21]

One reason that qualifying for an automatic zero EFC at college entry may be particularly important is that TEXAS Grants are only awarded to entering students. While FTIC and returning students see similar increases in total grant aid in the years after initially qualifying for an automatic zero, eligible FTIC students are significantly more likely to receive a TEXAS Grant in the first year and in the following academic year (Online Appendix Figure B.10). Automatic zero eligibility leads to a 4 percentage point increase in TEXAS Grant receipt for FTIC students, an effect that is similar in magnitude to the estimated impact on the probability of graduation within five, six, and seven years of entry. Thus, it is plausible that the TEXAS Grant contributes to the effectiveness of automatic zero eligibility in the first year of college.[22]

Our findings relate to two important features of the TEXAS grant program. First, institutions receive a fixed amount of TEXAS Grant funding and are required to use institutional funds to cover any remaining cost of tuition and fees that are not covered by federal grants or TEXAS Grant aid. Thus, institutions may have an incentive to target students who receive the most federal grant aid to minimize their own expenditures, which would explain why automatic zero eligibility increases the likelihood of receiving a TEXAS Grant. Second, a student awarded a TEXAS Grant is guaranteed to receive funding from the program for the next four years, conditional on meeting academic requirements and having unmet need. This is in contrast to Pell Grant aid and most other state grant programs, which can vary from year to year as a student's family circumstances change. As Online Appendix Figure B.11 shows, eligibility for an automatic zero EFC in one year is not predictive of receiving a $0 EFC in the next year. That we only

[21] We find suggestive evidence of larger attainment effects for students closer to college entry when we breaking up the sample of returning students by the number of years since entry. Despite similar effects of automatic zero eligibility on contemporaneous outcomes (Online Appendix Table B.13), effects on graduating within the next four to six years are decreasing in year of receipt (Online Appendix Figure B.8). The smaller sample sizes make these results and estimated effects on earnings by years since entry (Appendix Figure B.9) imprecise, but the pattern of graduation effects is consistent with grant aid being more effective when it is provided closer to college entry.

[22] For the increase in TEXAS receipt by FTIC students to fully explain effects on graduation, all marginal TEXAS recipients would need to be students who graduate if and only if eligible for the automatic zero EFC.

find significant attainment gains for FTIC students, the group for whom automatic zero eligibility increases TEXAS Grant receipt, suggests grant aid is more effective when it provides a conditional guarantee of consistent future funding.

6 Welfare Evaluation

We evaluate the welfare effect of increasing Pell Grant aid in Texas using the theoretical framework of Denning et al. (2017). This framework follows the sufficient-statistics approach outlined by Chetty (2009), deriving the first-order welfare effect of a marginal change in a vector of college prices. The framework is general in that it allows for college pricing schedules that are nonlinear in credits attempted, incorporates both the decision to attend college and the decision of where to attend, and allows for multiple forms of externalities. The analysis avoids interpersonal comparisons by considering a reform, such as an increase in grant aid, that the government funds by altering later-life transfers to/from the potential recipient to retain budget neutrality. The welfare effect of such a reform can be written as the sum of two terms: a direct effect on utility through changes in consumption smoothing and an indirect effect of the externalities generated by changes in behavior.

In our empirical setting, the general welfare formula can be simplified. First, the amount of federal grant aid received is affected directly in only one year and does not depend on credits attempted as long as the student attempts at least 12 credits per semester. The vast majority of students in the sample attempt sufficient credits, and we find economically and statistically insignificant effects of the grant on the probability of attempting 12 credits per semester. Second, we consider students enrolled in four-year public institutions at the automatic zero EFC eligibility threshold. For these students, we find no effect of eligibility for additional grant aid on enrollment or on the institution attended, allowing us to ignore effects on public subsidies to institutions.

We make two further simplifications that should work against finding additional grant aid would increase welfare. First, we ignore non-fiscal externalities, for which we do not have estimates. Prior literature (e.g., Lochner 2011) suggests that such externalities are positive on net. Second, we ignore direct effects of grant aid on utility, which would be a zero in the absence of credit constraints or other consumption-smoothing frictions. Direct effects are positive if credit constraints or other factors limit consumption in college years by inflating marginal utility in these years relative to years in which the grant would be repaid. Denning et al. (2017) conduct calibrations using consumption data which bound the direct consumption smoothing effect above zero for students from families with income near the automatic zero eligibility threshold. If direct effects and non-fiscal externalities are non-negative, then to document a welfare gain, it

is sufficient to show that net fiscal externalities of the increase in grant aid are positive.

To measure program costs, we take into account total cash flows between students and the public sector, abstracting from issues related to transfers between the federal government, state government, and public educational institutions. An advantage of our setting is that we observe all grants that students receive, whether from the Pell Grant program or from other sources. Thus, we can estimate the effect of automatic zero eligibility on grant aid received over most students' full college careers directly. Effects on total grant aid represent one of the two largest fiscal externalities generated by behavioral responses to automatic zero EFC eligibility.

Table 6 shows the effect of eligibility for an automatic zero EFC on total financial aid flows over the duration of the panel, a proxy that likely captures most of the lifetime effects on financial aid receipt. These estimates represent the linear combination of estimated effects of eligibility on the outcome of interest at baseline and in the following seven years shown in Figure 9.[23] The $653 increase in grants received by eligible students at college entry (Table 2) generates an increase of $1163 in total grant aid received over the duration of our panel (Table 6), a period over which most students have completed a degree or dropped out of college. Because automatic zero eligibility only mechanically affects grant aid in a student's first year, the increase in cumulative grant aid beyond the initial amount is likely generated by increased persistence and the increased probability of qualifying for a TEXAS Grant in later years. For returning students, the $758 initial increase in grant aid results in an increase of $1012 in cumulative grants. For both groups, impacts on cumulative borrowing are small and statistically insignificant. We also find no evidence of effects on years of attendance or expenditures on direct subsidies to public institutions attended by eligible students; point estimates for the latter are small, negative, and statistically insignificant.[24]

Turning from the costs in Table 6 to the benefits, we find significant increases for FTIC students. Earnings of FTIC students over the grant year and the next seven years increase by $3797, and estimated federal income and payroll tax liabilities each increase by about $550.[25] Effects on returning students' earnings and tax payments are roughly half as large and insignificant. It is possible that effects for returning students are positive but too small to detect without a longer panel, but effects calculated over the seven years our data span are not sufficiently precise to draw conclusions about the welfare effects of providing additional grant aid to returning students without strong assumptions.

[23] Students who leave school are classified as receiving $0 in grants and loans. Effects six years later are estimated using only students in the 2008 through 2010 cohorts and effects seven years later are estimated using only students in the 2008 and 2009 cohorts. To measure effects on cumulative payments by summing year-by-year point estimates, we must impose the assumption that effects of eligibility on grants, loans, and earnings six and seven years after entry are the same for earlier and later entry cohorts.

[24] Following Hoxby (forthcoming), we approximate the value of the direct subsidy provided to a given institution using data from the IPEDS and calculating average student-year expenditures on "core expenses" in excess of tuition payments.

[25] Estimated cumulative effects on tax payments are measured in real terms and no additional discounting is applied. Standard errors calculated using the Delta Method. Section 3 and Online Appendix D provide additional details relating to the calculation of tax liabilities.

We estimate that providing additional grant aid to FTIC students is not only welfare-enhancing but likely to fully be fully recouped by the government within 10 years. The initial grant increase of $653 is a transfer from a student's future tax payments, which means that it has only direct welfare effects that we have assumed are non-negative and thus can ignore. The indirect effect is the fiscal externality on public expenditures. Because we find no effect on public subsidies (through an enrollment response, institution choice, or years of attendance), the fiscal externality equals the difference between the effect on income tax payments and the effect on grant aid paid after the student's first year ($510). The increase in income tax liabilities exceeds this amount within the sample period, and therefore we can conclude that net fiscal externalities are positive and that a compensated increase in grant aid increases welfare. Under relatively weak assumptions, even the additional grant aid automatic zero eligible students receive in their first year will be recouped via increased tax payments, meaning that compensation through increases in future taxes would not be required. We cannot say whether the earnings effects (and resulting income tax gains) will continue to grow over the long-run, but if earnings gains remain at the level we observe at the end of our panel, the additional grant aid received by eligible students in their first year will be fully recovered in three more years and each additional year in which earnings gains are nonzero will generate additional revenue. Earnings gains need not even persist for more than another year if we include the increases in FICA taxes collected. Thus, even if we ignore direct consumption-smoothing effects and any non-fiscal externalities, both of which we expect to be positive on net, our results indicate that additional grant aid raises welfare for these students and likely pays for itself several times over.

7 Conclusion

Using student-level administrative data from Texas and a regression discontinuity design, we show that eligibility for additional grant aid substantially increases poor students' postsecondary attainment. Eligibility increases enrollment of students at community colleges by 3 to 9 percent. Four-year college enrollment is unaffected, allowing us to obtain unbiased estimates of effects on graduation, earnings, and tax payments, all of which are positive and statistically significant when students gain eligibility for additional grant aid at college entry. We find no statistically significant effects of eligibility on returning students' graduation, earnings, or taxes. For students entering four-year institutions, increasing grant aid would enhance welfare and even pay for itself over a relatively short time horizon. Eligibility for additional aid leads students to pay significantly more income taxes, and this positive fiscal externality is large relative to the costs of providing them with additional financial support.

Our results provide suggestive evidence on the mechanisms by which grant aid improves student out-

comes. In our setting, aid awarded after a student has been accepted to college appears to be more pivotal for enrollment in community colleges than in four-year institutions. In four-year colleges, effects on graduation may be larger for entering students because the Pell Grant aid crowds in TEXAS Grant aid in the first year or because resources received at the beginning of college can change a student's trajectory. That earnings effects are also larger for FTIC students suggests that degree completion is an important mediator. Impacts on FTIC students' graduation and earnings remain positive for the duration of our panel, seven years after grant receipt, suggesting that the aid not only speeds up degree receipt but increases the overall number of college graduates. In this setting, the benefits of additional aid provided to low-income students are substantial, and among students entering public universities in Texas, increasing grant aid pays for itself through financial gains for the public.

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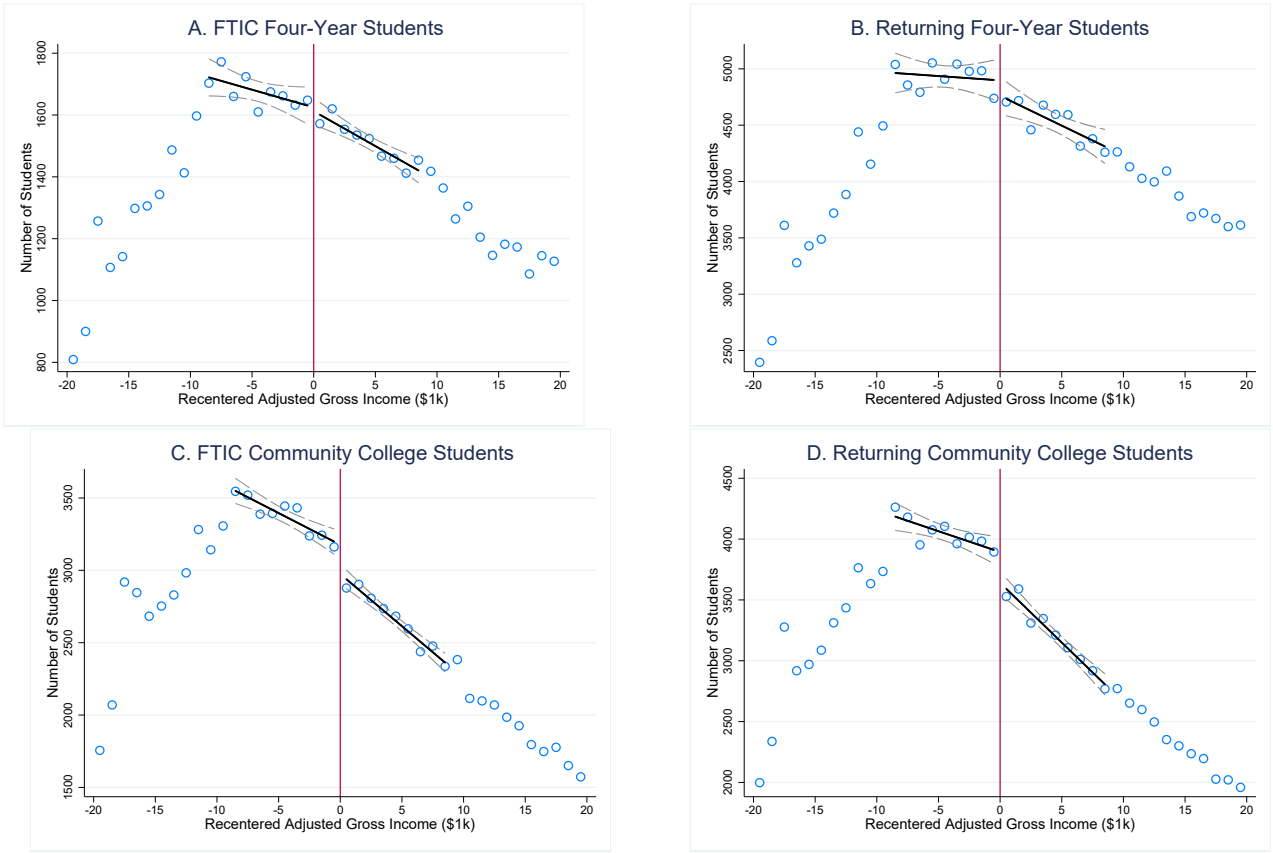
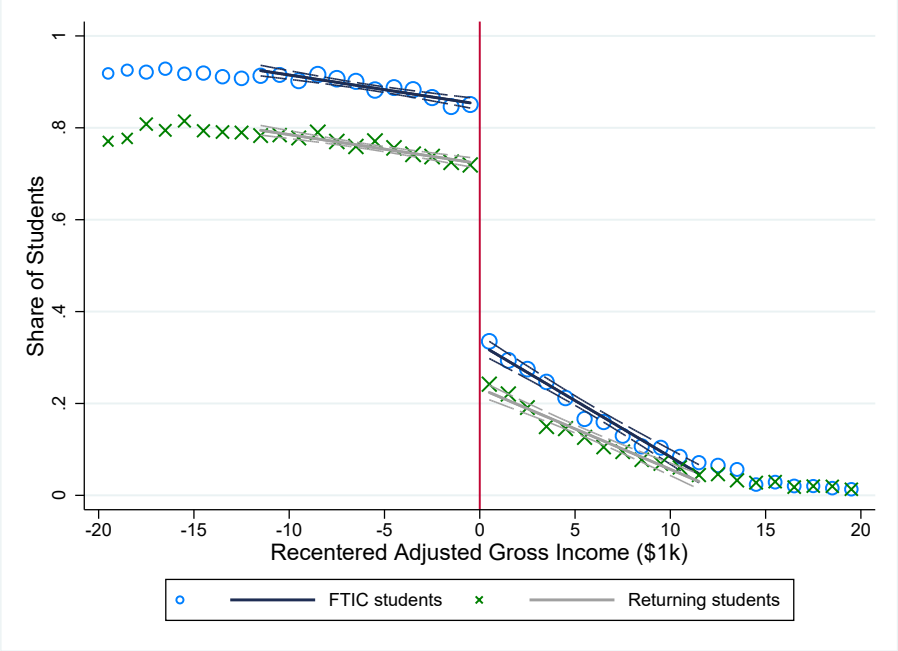
Figures and Tables

Figure 1: Number of Students by Distance to the Automatic Zero EFC Threshold



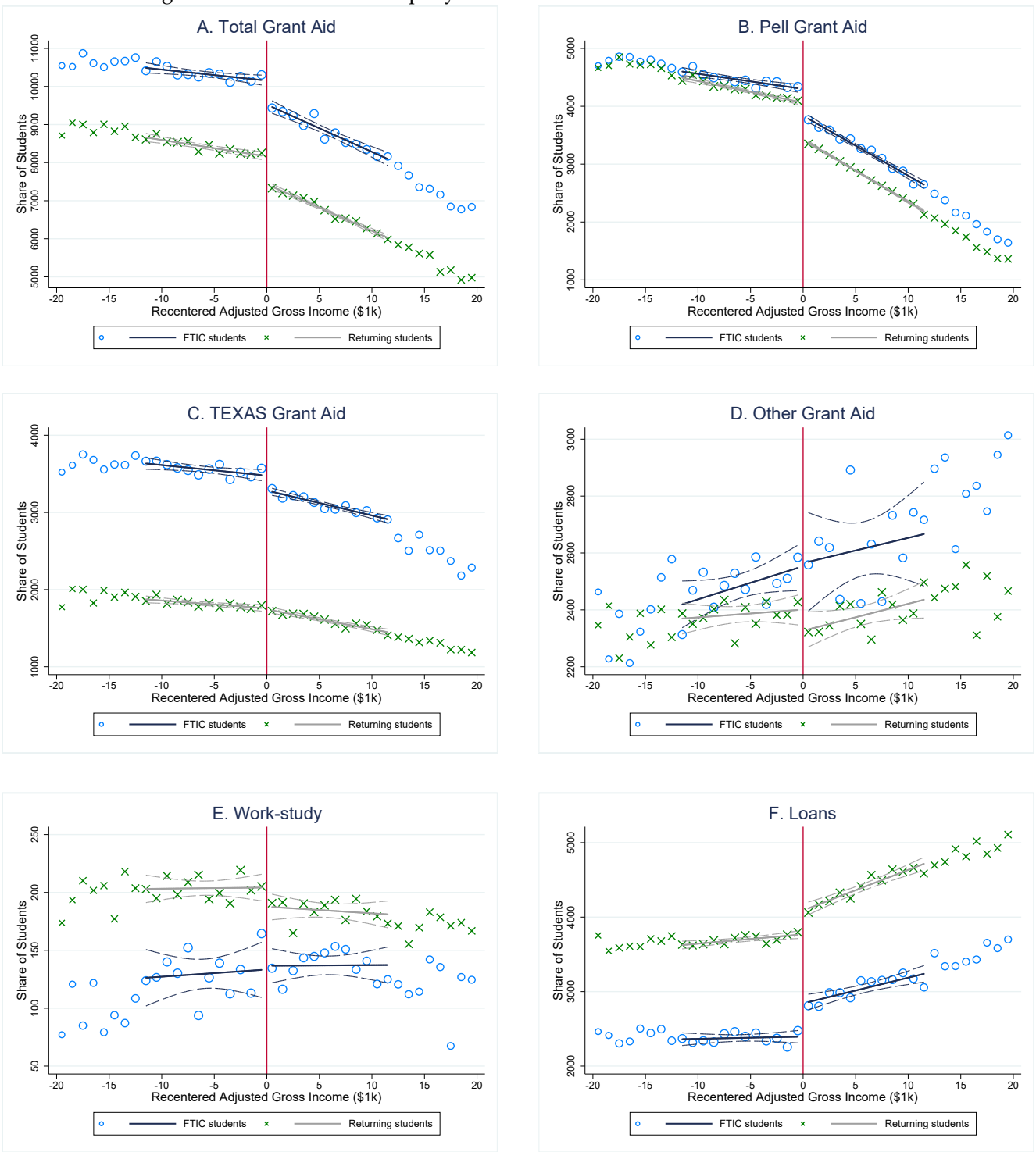
Notes: FTIC = first-time-in-college. Sample in Panel A (B) includes first-time (returning) dependent undergraduate students who enrolled in a four-year Texas public institution in 2008 through 2011. Sample in Panel C (D) includes first-time (returning) dependent undergraduate students who enrolled in a Texas community college in 2008 through 2011. Students with AGIs at $1000 intervals are excluded. Each marker represents the number of students within a given $1000 AGI bin. Solid dark lines represent estimates from a local linear regression of student enrollment on $\widetilde{AGI}$, estimated separately by eligibility, dashed light lines represent corresponding 95 percent confidence interval.

Figure 2: Share of Four-Year Students with $0 EFC by Distance to the Automatic Zero EFC Threshold



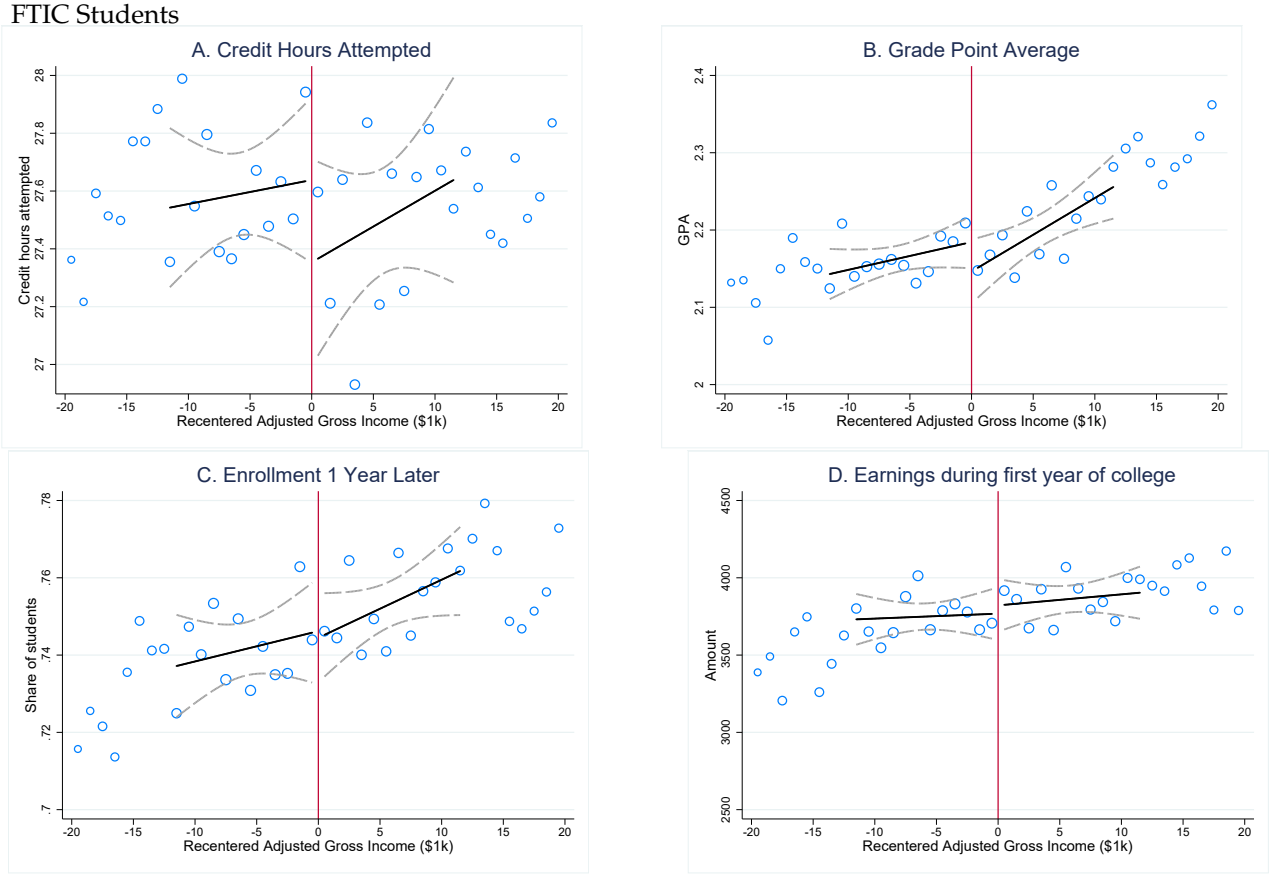
*Note*s: First-time-in-college and returning dependent undergraduate students who enrolled in a four-year Texas public institution in 2008 through 2011 and whose family AGI fell within $20,000 of the income eligibility threshold for an automatic zero EFC. Students with AGIs at multiples of $1000 are excluded. Each marker represents the average percentage of students with a $0 EFC in the $1000 AGI bin. Larger circles represent a larger underlying sample size. Solid dark lines represent estimates from a local linear regression of the share of students with an EFC = $0 on $\widetilde{AGI}$, estimated separately by eligibility, and weighted by the number of students in the bin. Dashed light lines represent corresponding 95 percent confidence interval.

Figure 3: Financial Aid Receipt by Distance to the Automatic Zero EFC Threshold



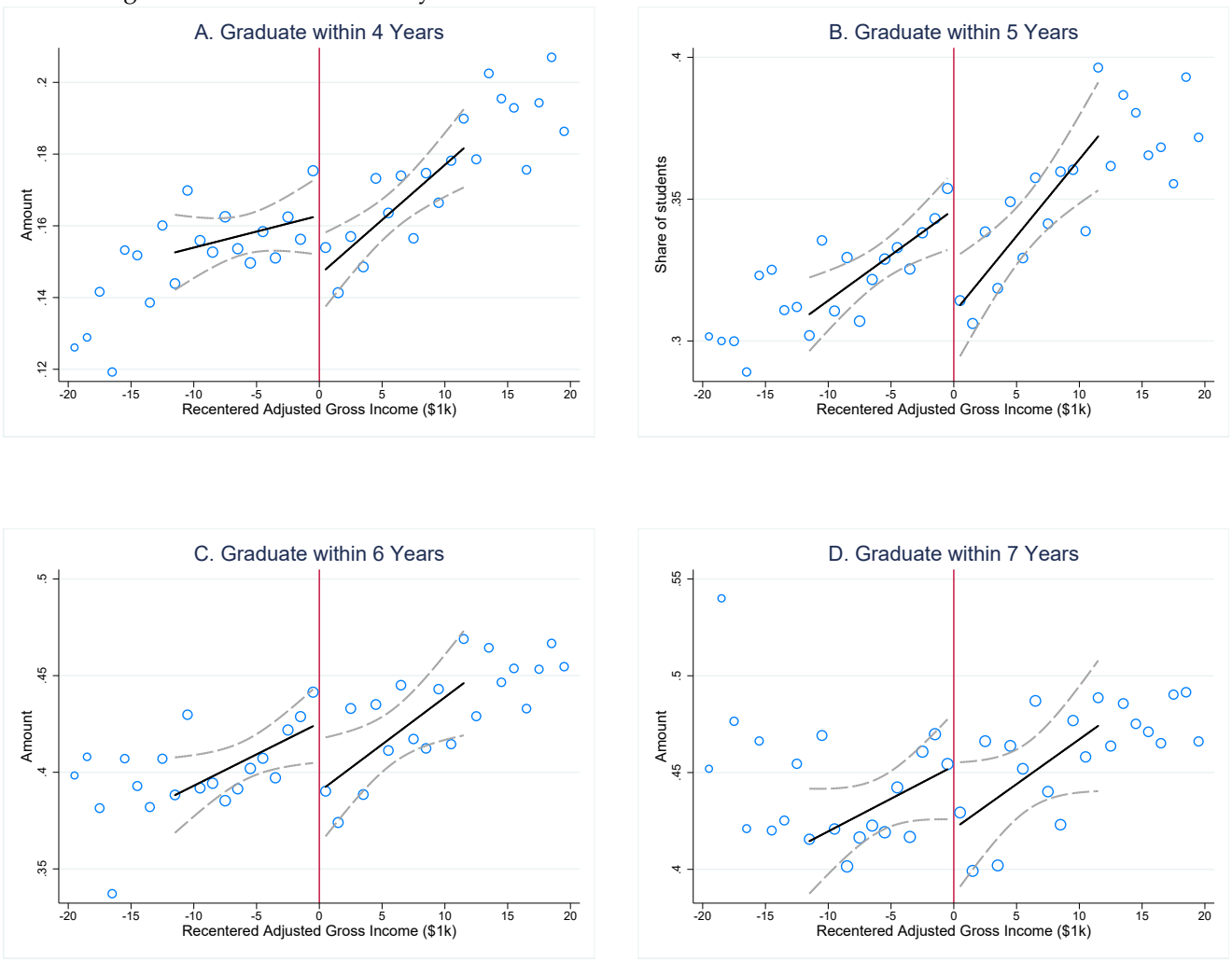
Notes: First-time-in-college and returning dependent undergraduate students who enrolled in a four-year Texas public institution in 2008 through 2011 and whose family AGI fell within $20,000 of the income eligibility threshold for an automatic zero EFC. Students with AGIs at multiples of $1000 are excluded. Each marker represents the average amount of grant aid from all sources (Panel A), Pell Grant aid (Panel B), TEXAS Grant aid (Panel C), other grant aid (Panel D), work-study (Panel E), or loans (Panel E) received by students within a $1000 AGI bin. Larger circles represent a larger underlying sample size. Solid dark lines represent estimates from a local linear regression of outcome on $\widetilde{AGI}$, estimated separately by eligibility, and weighted by the number of students in the bin. Dashed light lines represent corresponding 95 percent confidence interval. Total grant aid includes Pell, Texas, other state, other federal, and institutional grant aid. All dollar amounts adjusted to represent constant 2013$.

Figure 4: Short-Run Academic and Financial Outcomes by Distance to the Automatic Zero EFC Threshold: FTIC Students



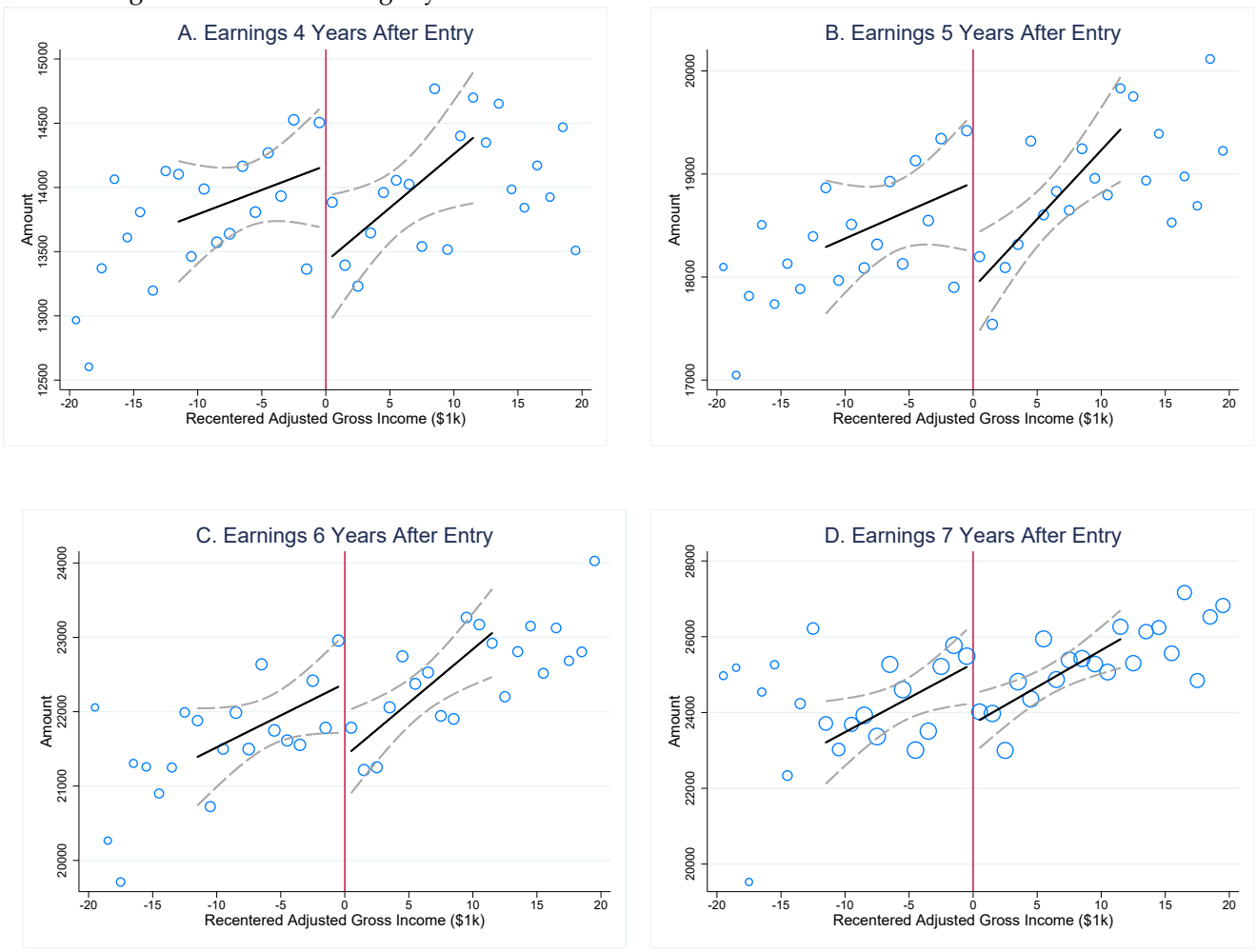
Notes: First-time-in-college dependent undergraduate students who enrolled in a four-year Texas public institution in 2008 through 2011 and whose family AGI fell within $20,000 of the income eligibility threshold for an automatic zero EFC. Students with AGIs at multiples of $1000 are excluded. Each marker represents the average number of credit hours attempted (Panel A), average GPA (Panel B), share of students who reenrolled the next year (Panel C), or average earnings (Panel D) in the year of college entry within a $1000 AGI bin. Larger circles represent a larger underlying sample size. Solid dark lines represent estimates from a local linear regression of outcome on $\widetilde{AGI}$, estimated separately by eligibility, and weighted by the number of students in the bin. Dashed light lines represent corresponding 95 percent confidence interval. Earnings limited to students in UI-covered jobs in Texas. All dollar amounts adjusted to represent constant 2013$.

Figure 5: Graduation Rates by Distance to the Automatic Zero EFC Threshold: FTIC Students



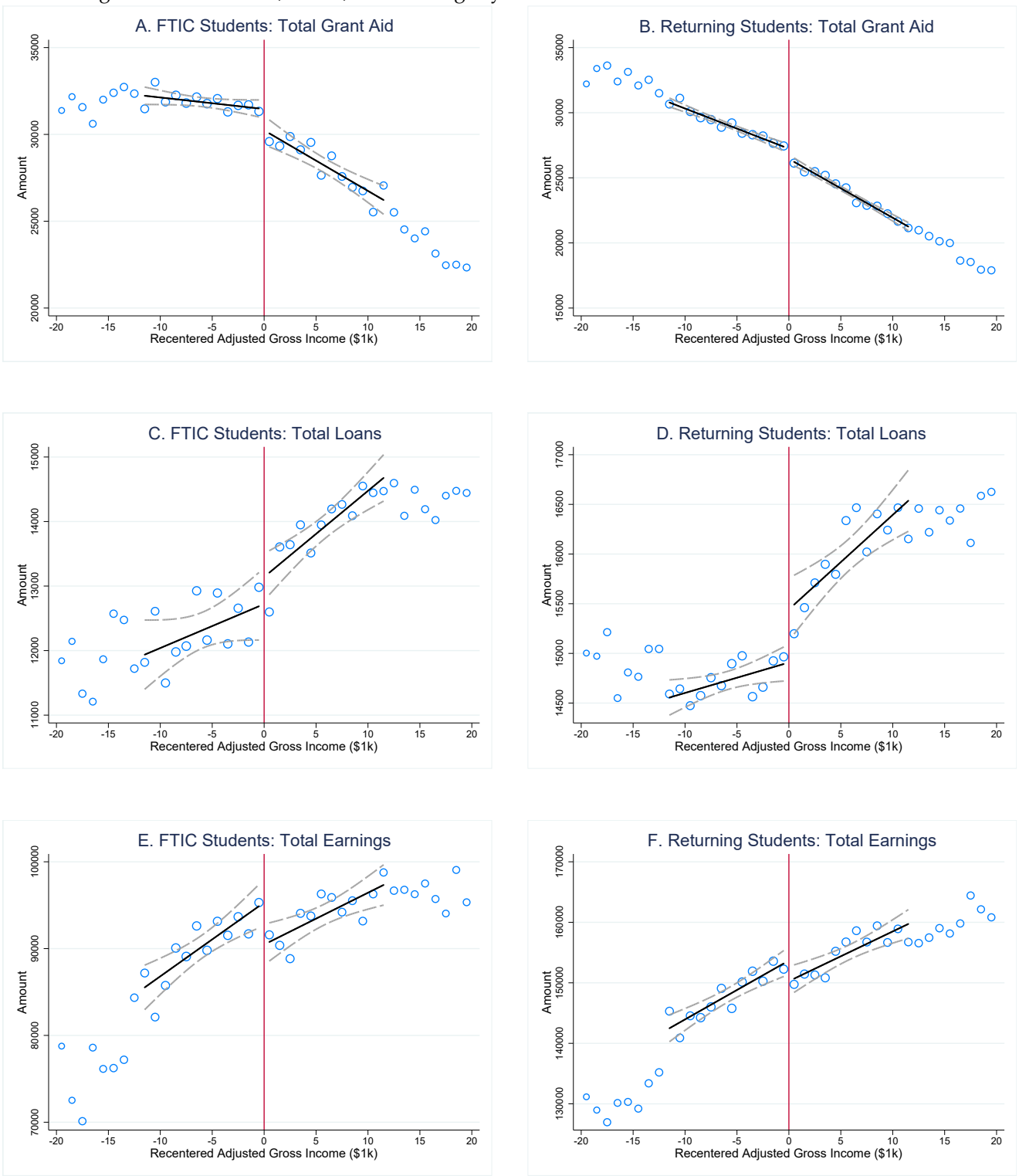
Notes: See Figure 4 notes for sample description. Each marker represents the share of students receiving a bachelor's degree within the specified number of years since entry within a $1000 AGI bin. Larger circles represent a larger underlying sample size. Solid dark lines represent estimates from a local linear regression of outcome on $\widetilde{AGI}$, estimated separately by eligibility, and weighted by the number of students in the bin. Dashed light lines represent corresponding 95 percent confidence interval.

Figure 6: Annual Earnings by Distance to the Automatic Zero EFC Threshold: FTIC Students



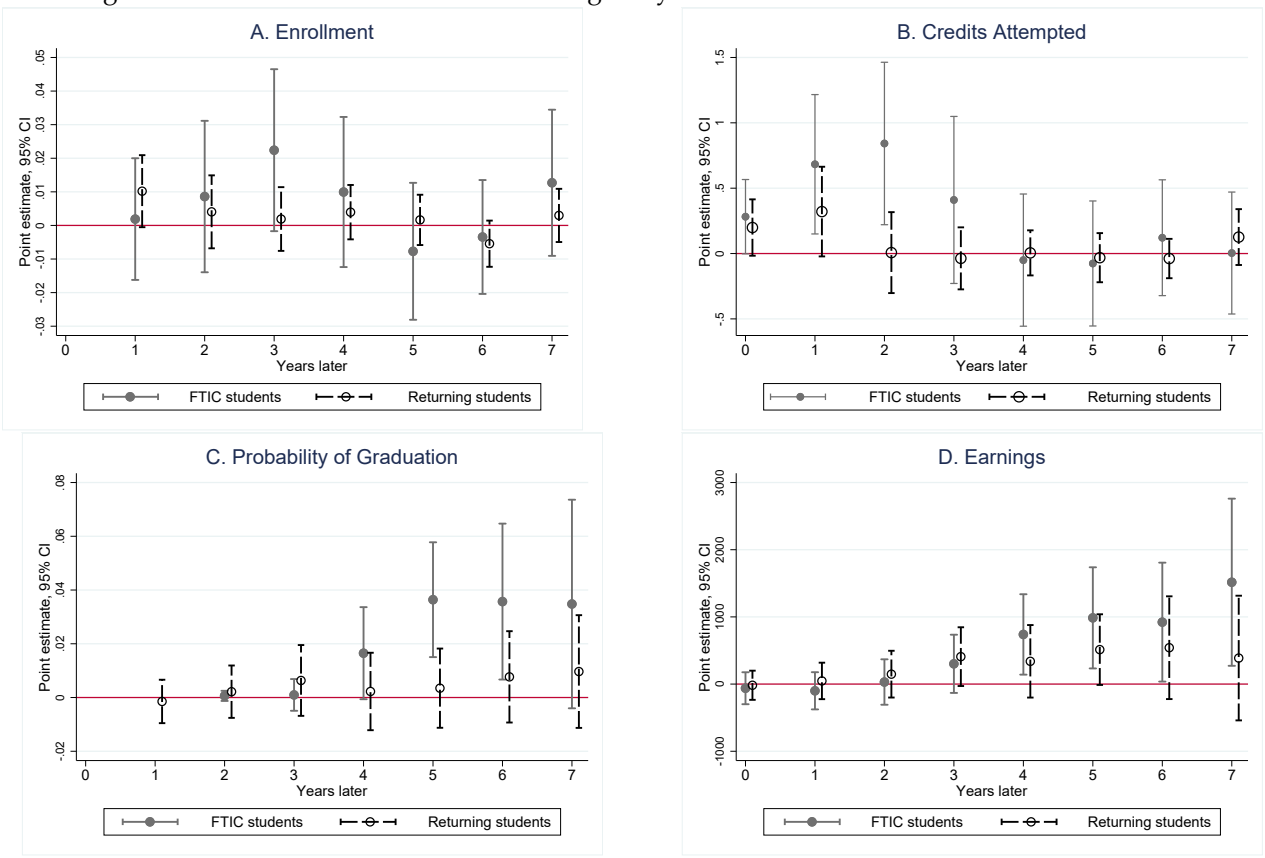
Notes: See Figure 4 notes for sample description. Each marker represents average earnings received by students in the specified number of years since entry within a $1000 AGI bin. Larger circles represent a larger underlying sample size. Solid dark lines represent estimates from a local linear regression of outcome on $\widetilde{AGI}$, estimated separately by eligibility, and weighted by the number of students in the bin. Dashed light lines represent corresponding 95 percent confidence interval. Earnings are limited to those received in UI-covered jobs in Texas. All dollar amounts adjusted to represent constant 2013$.

Figure 7: Total Grants, Loans, and Earnings by Distance to the Automatic Zero EFC Threshold



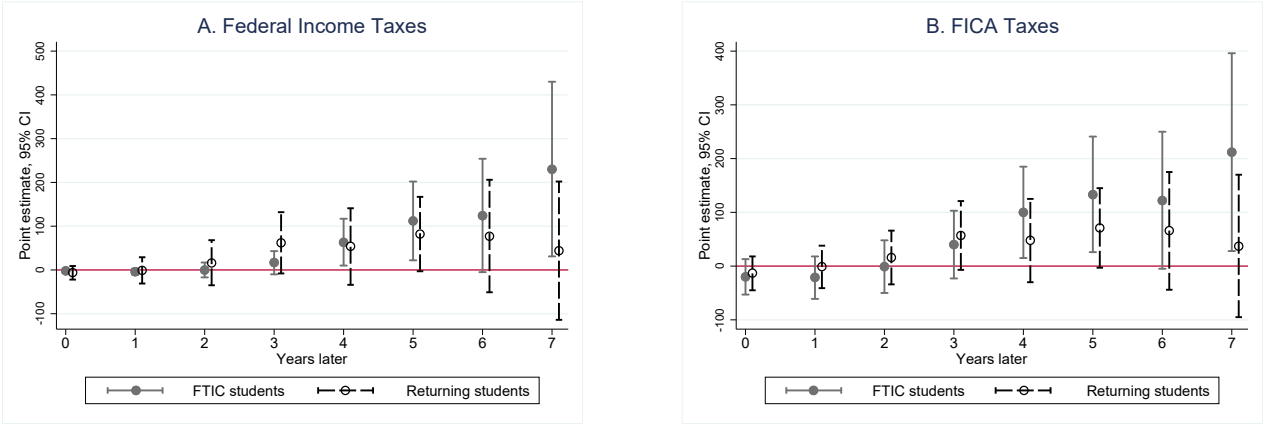
Notes: See Figure 2 notes for sample description. Each marker represents average cumulative grant aid (Panels A and B), federal loans (Panel C and D), or earnings (Panel E and F) received by students over the duration of years in which they are observed within a given $1000 AGI bin. Amounts are summed over all years in which a given student is observed (between 5 and 7 years). Standardized AGI represents the distance from the automatic zero EFC cut-off in the year of college entry. Earnings are limited to those received in UI-covered jobs in Texas. Larger circles represent a larger underlying sample size. All dollar amounts adjusted to represent constant 2013$.

Figure 8: Effects of Automatic Zero EFC Eligibility on Academic and Labor Market Outcomes



Notes: First-time-in-college and returning dependent undergraduate students who enrolled in a four-year Texas public institution in 2008 through 2011 and whose family AGI fell within $12,000 of the eligibility threshold for an automatic zero EFC. Students with AGIs at $1000 intervals are excluded. Point estimates and 95% CI from regressions of the probability of reenrollment (Panel A), credits attempted (Panel B), probability of bachelor's degree receipt (Panel C), or annual earnings (Panel D) on eligibility for the automatic zero EFC, a linear term in distance from the threshold (allowed to vary on either side), and indicators for parent education, race, gender, age, Texas residency, and cohort. Confidence intervals constructed using robust standard errors clustered at initial institution by entry cohort level. Earnings limited to students in UI-covered jobs in Texas. All dollar amounts adjusted to represent constant 2013$.

Figure 9: Effects of Automatic Zero EFC Eligibility on Tax Receipts



Notes: See Figure 8 notes for sample and specification. Federal income and payroll taxes imputed using NBER TAXSIM (see Online Appendix D for additional details). All dollar amounts adjusted to represent constant 2013$.

Table 1: Sample Demographics and Contemporaneous Finances

	First-time-in-college students			Returning students		
	(1) Full sample	(2) AZ eligible	(3) AZ ineligible	(4) Full sample	(5) AZ eligible	(6) AZ ineligible
A. Student demographics						
Male	0.45	0.45	0.46	0.43	0.43	0.43
Age	18.6	18.6	18.6	20.9	20.9	20.9
Texas Resident	0.97	0.97	0.96	0.98	0.98	0.98
Race						
Asian	0.05	0.05	0.05	0.08	0.08	0.08
Black	0.24	0.23	0.26	0.20	0.19	0.22
Hispanic	0.21	0.19	0.24	0.25	0.22	0.28
White	0.47	0.51	0.43	0.45	0.49	0.41
Parental education						
Father: <HS	0.13	0.15	0.12	0.14	0.15	0.12
Father: HS degree	0.46	0.45	0.47	0.44	0.43	0.45
Father: college degree	0.22	0.20	0.25	0.26	0.24	0.28
Mother: <HS	0.12	0.14	0.10	0.13	0.15	0.10
Mother: HS degree	0.48	0.49	0.48	0.48	0.48	0.48
Mother: college degree	0.29	0.26	0.32	0.29	0.26	0.33
B. Financial aid						
EFC = 0	0.56	0.89	0.19	0.46	0.76	0.13
Pell Grant aid	$3,877	$4,454	$3,237	$3,569	$4,282	$2,797
Texas Grant aid	$3,340	$3,558	$3,097	$1,709	$1,817	$1,593
Total Grants	$9,605	$10,326	$8,805	$7,600	$8,417	$6,717
Loans	$2,693	$2,378	$3,042	$4,038	$3,696	$4,408
Earnings	$3,803	$3,749	$3,863	$7,312	$7,150	$7,487
Work Study	$133	$130	$137	$194	$204	$184
Observations	37,227	19,583	17,644	110,607	57,480	53,127

Notes: First-time-in-college and returning dependent undergraduate students who enrolled in a four-year Texas public institution in 2008 through 2011 and whose family AGI fell within $12,000 of the eligibility threshold for an automatic zero EFC. Students with AGIs at $1000 intervals are excluded. Race and parent education categories will not sum to 100 percent due to missing values. All dollar amounts adjusted for inflation (2013$).

Table 2: The Effect of Automatic Zero Eligibility on Contemporaneous Financial Outcomes

	(1) EFC=0	(2) Total grant aid	(3) Pell Grant aid	(4) TEXAS Grant aid	(5) Other grant aid	(6) Work-study	(7) Earnings	(8) Loans
A. FTIC students								
Automatic zero eligible	0.519***	653***	489***	151**	25	-5	-134	-343***
	(0.014)	(95)	(37)	(63)	(83)	(14)	(112)	(63)
Mean | ineligible	0.33	$9,520	$3,836	$3,285	$2,560	$138	$3,829	$2,835
B. Returning students								
Automatic zero eligible	0.487***	758***	659***	-10	99**	17*	-88	-225***
	(0.011)	(73)	(39)	(34)	(46)	(10)	(108)	(47)
Mean | ineligible	0.21	$5,680	$3,025	$997	$1,678	$151	$10,103	$4,649

Notes: See Table 1 notes for sample description. Point estimates from OLS regressions of the dependent variable specified in each column on eligibility for the automatic zero EFC. All models also include controls for a linear term in distance from the AGI threshold (allowed to vary on either side of the threshold), parent education, race, gender, age, Texas residency, and entry cohort. Robust standard errors, clustered by initial institution by entry cohort, in parentheses; *** p<0.01, ** p<0.05, * p<0.1. "Mean | ineligible" represents the limit of the expected value of the dependent variable as the AGI threshold is approached from above. All dollar amounts adjusted for inflation (2013$).

Table 3: The Effect of Automatic Zero Eligibility on Contemporaneous Academic Outcomes

	(1) Credit hours attempted	(2) Persistence	(3) GPA
A. FTIC students			
Automatic zero eligible	0.256*	0.0005	0.031
	(0.138)	(0.009)	(0.026)
Mean | ineligible	27.4	0.74	2.15
B. Returning students			
Automatic zero eligible	0.220**	0.010*	0.014
	(0.109)	(0.005)	(0.013)
Mean | ineligible	25.1	0.56	2.64

Notes: See Table 1 notes for sample description. See Table 2 notes for specification. Robust standard errors, clustered by initial institution by entry cohort, in parentheses; *** p<0.01, ** p<0.05, * p<0.1. "Mean | ineligible" represents the limit of the expected value of the dependent variable as the AGI threshold is approached from above the threshold.

Table 4: IV Estimates of the Effect of Grant Aid on Longer-Run Academic Outcomes

X =	*1*	*2*	*3*	*4*	*5*	*6*	*7*
A. New students: enrollment X years later							
Baseline grant aid ($1k)	0.001	0.008	0.029*	0.013	-0.014	-0.011	0.026
	(0.014)	(0.016)	(0.017)	(0.017)	(0.016)	(0.017)	(0.031)
Mean | ineligible	0.74	0.61	0.55	0.38	0.20	0.10	0.07
Observations	37,227	37,227	37,227	37,227	26,707	17,308	8,225
B. Returning students: enrollment X years later							
Baseline grant aid ($1k)	0.012*	0.003	0.001	0.004	0.002	-0.011*	0.004
	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)
Mean | ineligible	0.56	0.28	0.13	0.06	0.04	0.03	0.02
Observations	110,603	110,603	110,603	110,603	79,215	51,939	25,131
C. New students: graduate within X years							
Baseline grant aid ($1k)	--	0.001	0.001	0.022*	0.051***	0.050**	0.062*
	--	(0.001)	(0.005)	(0.012)	(0.015)	(0.021)	(0.036)
Mean | ineligible	--	<0.01	0.01	0.15	0.31	0.39	0.42
Observations	--	37,227	37,227	37,227	37,227	26,707	17,308
D. Returning students: graduate within X years							
Baseline grant aid ($1k)	-0.002	0.003	0.007	0.001	0.002	0.009	0.015
	(0.005)	(0.006)	(0.008)	(0.009)	(0.009)	(0.011)	(0.016)
Mean | ineligible	0.35	0.59	0.72	0.78	0.80	0.82	0.82
Observations	110,603	110,603	110,603	110,603	110,603	79,215	51,939

Notes: See Table 1 notes for sample description. Each cell within a panel displays estimates of the impact of baseline automatic-zero EFC eligibility on the specified outcome, scaled per additional $1000 in baseline grant aid. Column headings represent the number of years since baseline. All models also include controls for a linear term in distance from the AGI threshold (allowed to vary on either side of the threshold). Robust standard errors, clustered by initial institution by entry cohort, in parentheses; *** p<0.01, ** p<0.05, * p<0.1. "Mean | ineligible" represents the limit of the expected value of the dependent variable as the AGI threshold is approached from above the threshold. All dollar amounts adjusted for inflation (2013$).

Table 5: IV Estimates of the Effect of Grant Aid on Returning Longer-Run Labor Market Outcomes

X =	*1*	*2*	*3*	*4*	*5*	*6*	*7*
A. New students: earnings X years later							
Baseline grant aid ($1k)	-220	-8	411	1033**	1369**	1270*	2916*
	(208)	(255)	(326)	(435)	(563)	(702)	(1545)
Mean | ineligible	$5,651	$7,483	$9,517	$13,422	$17,914	$21,428	$23,728
Observations	37,227	37,227	37,227	37,227	37,227	26,707	17,308
B. Returning students: earnings X years later							
First year grant aid ($1k)	16	154	502*	423	618*	668	458
	(181)	(228)	(282)	(347)	(330)	(564)	(874)
Mean | ineligible	$15,803	$21,344	$25,338	$28,727	$31,550	$33,798	$35,723
Observations	110,603	110,603	110,603	110,603	110,603	79,215	51,939

Notes: See Table 4 notes for sample and specification. Robust standard errors, clustered by initial institution by entry cohort, in parentheses; *** p<0.01, ** p<0.05, * p<0.1. "Mean | ineligible" represents the limit of the expected value of the dependent variable as the AGI threshold is approached from above the threshold. All dollar amounts adjusted for inflation (2013$).

Table 6: Cumulative Impacts on Financial Aid, Earnings, and Federal Taxes

	(1) Grants	(2) Loans	(3) Earnings	(4) Fed. income taxes	(5) FICA taxes
A. FTIC students					
Automatic zero eligible	1163***	-277	3797**	540***	565**
	(436)	(383)	(1676)	(201)	(249)
Mean | ineligible	$30,708	$15,279	$102,972	$4,088	$15,347
B. Returning students					
Automatic zero eligible	1012***	-195	1869	328	280
	(168)	(146)	(1431)	(233)	(213)
Mean | ineligible	$10,175	$46,765	$202,386	$17,357	$30,127

Notes: See Table 1 notes for sample description. See Table 2 notes for specification. Each column displays the linear combination of the sum of point estimates displayed in Figure 8 (Panel D), Figure 9, and Online Appendix Figure B.10 (Panel A). Robust standard errors, clustered by initial institution by entry cohort, in parentheses; *** p<0.01, ** p<0.05, * p<0.1. All dollar amounts adjusted for inflation (2013$).