Not Whether, but Where? Pell Grants and College Choices

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Abstract

Pell grants are the largest financial aid vehicle in the United States, and yet, their role in shaping students' college choices is not clear. Drawing on the enrollment decisions of four cohorts of Tennessee high school graduates and quasi-experimental Pell eligibility derived from federal formulas, we find little evidence that marginal Pell eligibility affects whether or where students enroll in college. Inframarginal estimates suggest that students sort into colleges with 11.6 cents higher tuition per dollar of Pell aid, although other measures of college quality do not significantly improve over the counterfactual. An investigation into mechanisms that might be muting student responses to Pell favors the application process itself over grant size or institutional aid flexibility.

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1 Introduction

Over 9.4 million students received Pell grants, the largest source of federal grant aid in higher education, in the 2011-2012 academic year, amounting to $33.6 billion in expenditures (U.S. Department of Education, 2012). This extensive grant program intends to increase access to college for financially constrained students, but the introduction of the program in 1973 was not linked to gains in college enrollment for lower-income students (Hansen, 1983; Kane, 1995), with notable exceptions provided by older, non-traditional students (Seftor & Turner, 2002).[1] Financial aid programs other than Pell increase college enrollment at a rate of 3-6 percentage points per nominal $1,000 in aid (Deming & Dynarski, 2010; Dynarski & Scott-Clayton, 2013), but nonetheless, the idea that traditional student demand for college is insensitive to Pell eligibility is not altogether surprising. Foremost, the application process for federal financial aid is complex and can stretch well into a student's senior year of high school, which weakens and delays the communication of aid eligibility to students on the margin of going to college (Dynarski & Scott-Clayton, 2006, 2008; Dynarski & Wiederspan, 2012; Dynarski et al., 2013).[2] Easing this process meaningfully increases college enrollment (Bettinger et al., 2012). Second, applicants observe Pell eligibility at the same time as institutions, who may capture a portion of federal funds by reducing institutional aid (Turner, 2017). And third, marginal Pell eligibility is associated with a fairly small grant, so local treatment effects could understate the impact of Pell grants more broadly. With these ideas in mind, two of the remaining questions about Pell eligibility and college-going center around students' choice of college, conditional on enrollment, and treatment effects for Pell grants larger than the modest scholarship available at the beginning of the phase-in range.

We utilize quasi-experimental changes in Pell eligibility as determined by values of "expected family contribution," a relatively opaque construct of federal aid processing, to estimate the effect of Pell grants on college enrollment for four cohorts of Tennessee high school graduates, and we go on to examine whether Pell eligibility affects *where* a student chooses to enroll, in terms of college

[1] Limited or null effects on the college entry margin do not rule out a response from enrolled students to the loss of Pell (Bettinger, 2004; Scott-Clayton & Schudde, 2016).

[2] By contrast, eligibility criteria for merit aid programs are widely publicized and tied to standardized test scores or grade point averages. Students are well-informed as to their merit aid eligibility, sometimes long before they start applying to college. Perhaps consequentially, merit aid eligibility has been shown to affect students' college enrollment choices (Goodman, 2008; Bruce & Carruthers, 2014; Cohodes & Goodman, 2014).

sector and college quality.[3] Are Pell recipients more inclined to enroll out-of-state? Are students receiving the Pell more likely to attend four-year universities rather than two-year colleges? Do Pell recipients attend higher quality institutions? With scattered exceptions, we detect little to no effect of minimum Pell eligibility on college choices in terms of college sector, college quality, or enrollment itself. Confidence intervals rule out enrollment effects exceeding 0.7 percentage points for a grant discontinuity measuring $400-976. College quality indicators such as graduation rates and instructional spending change by no more than, respectively, 1.8 percentage points and $341 per student. These treatment effects are small relative to the experimental effect of providing students with clear information on net price, which leads students to choose institutions with 3 percentage point higher graduation rates and $1,418 greater per-student instructional spending (Hoxby & Turner, 2014). Two noteworthy exceptions are thus: we find that (1) marginally Pell-eligible males enroll in more selective colleges relative to marginally ineligible males, and (2) females substitute into out-of-state four-year public colleges upon gaining Pell eligibility, although both effects are small enough to go unnoticed in the full sample. We go on to explore potential mechanisms, with results favoring the application process over grant size or intuitional flexibility to capture Pell aid. Students benefitting from a simplified application rule were more likely to choose costlier private institutions with less of a research focus, and recipients of a state grant that prioritizes earlier aid applications tended to choose schools targeted by the grant.

We then apply a method introduced by Angrist & Rokkanen (2015) to assess whether the local impact of the Pell grant generalizes away from the eligibility threshold, where the grant is more generous, both for the application year and likely for later years, and where needier students may be more aware of aid eligibility. Inframarginal Pell students enroll in institutions where out-of-state tuition and fees are modestly higher than the counterfactual (at most 11.6 cents per dollar of Pell aid), but Pell-eligible students are otherwise no different than the counterfactual in terms of where they choose to enroll in college. We conclude that the Pell grant system as it stood through the late 2000s had no discernible effect on whether traditional-aged Tennesseans went to college and at best modest effects on where they went to college. This underscores the promise of recent developments in the application timeline for federal financial aid if these policy changes enhance

[3]Throughout the study we use "college quality" interchangeably with "college selectivity," although we acknowledge that selectivity measures do not equate with institutional value added.

students' awareness of Pell eligibility when they are planning for college.

To date, researchers have exploited the Pell eligibility formula to examine year-to-year persistence (Bettinger, 2004), the timeliness of college enrollment (Rubin, 2011), borrowing (Marx & Turner, 2018), institutional aid (Turner, 2017), and earnings after college (Denning et al., 2018) but it is not yet clear if and how Pell grants affect student choices along the spectrum of college quality.[4] The same Pell award can be used at almost any institution, so Pell has the potential to help needy students enroll in better colleges. One reason for this gap in the literature is the rare confluence of data on complete cohorts of high school graduates, linked to both college enrollment outcomes and detailed data from financial aid applications. Marx & Turner (2018), Denning et al. (2018), and Turner (2017) provide three close exceptions. Concurrent with their analysis of Pell's effect on student borrowing in the City University of New York (CUNY) system, Marx & Turner (2018) find no evidence of systematic application, enrollment, or sorting among CUNY applicants with marginal Pell eligibility. Similarly, recent studies of long-term effects of aid (Denning et al., 2018) and campus responses to student aid eligibility (Turner, 2017) find little to no change in students' college choices at Pell schedule discontinuities among enrolled students. We add to this body of work with a deeper analysis of the enrollment effects of minimum Pell eligibility: beginning with cohorts of high school graduates rather than college enrollees, examining a rich array of their college choices, and looking beyond local treatment effects to consider the effect of inframarginal Pell eligibility.

2 Conceptual and Policy Framework

The federal Pell Grant program initially began under Title IV of the Higher Education Act of 1965. The specific timeline of Pell grant determination illustrates how students might leverage the grant to shop among college options as well as the difficulties of doing so in reality. Students seeking Pell aid as well as other federal grants, subsidized loans, or work-study programs must complete a Free Application for Federal Student Aid (FAFSA). Until recently, traditional students started

[4]The effect of Pell eligibility on admission decisions is also unclear. Institutions are capacity constrained in the short run, and admission itself may respond to Pell eligibility, particularly as more selective institutions come under scrutiny for low rates of Pell-eligible enrollment (Carnevale & Van Der Werf, 2017). Institutional preferences favoring Pell students, translated into a higher likelihood of admission or greater aid, should expand college opportunities at the eligibility threshold.

filing FAFSAs in January for fall enrollment the same year, and colleges often require that high school seniors submit their FAFSA between February and March in order to be given priority for need-based institutional aid.[5]

The FAFSA collects demographic information, federal income tax information, family size, the number of family members in college (excluding parents), and other financial data such as assets and untaxed income. Students indicate at least one college to receive the output of FAFSA processing. The 2006-2009 cohorts in our study could submit the FAFSA electronically or by mail. Up to four colleges could be listed on paper FAFSAs while online applications allowed for six, increasing to ten with 2009 applicants (U.S. Department of Education, 2007).

Once a student submits her FAFSA, the Central Processing System calculates her Expected Family Contribution (EFC). EFC is the amount that the student or her family are expected to provide for college expenses, based on ability to pay. To begin calculating EFC, allowances for taxes and basic living expenses are subtracted from the family's income to yield "available" income. The family's available income along with a percentage of net assets is divided by the number of dependents in college (including the applicant) to generate EFC.[6] Within three days to three weeks after a student submits her FAFSA, the Central Processing System sends the student a Student Aid Report, and all schools listed on the student's FAFSA receive an Institutional Student Information Record. The Student Aid Report lists the student's FAFSA information as well as her EFC and potential Pell grant eligibility.

At this point a student is notified that she *may be* eligible for a Pell grant but she is not made aware of the amount. Pell grants are a simple function of EFC, and Pell-to-EFC schedules are published each year after federal appropriations have been determined (typically in January). In principle, students can easily find out what their Pell grant should be upon learning their EFC. But the Student Aid Report – the primary communication between the federal aid process and students

[5]The four cohorts under study were required to use the prior year's tax information on their FAFSAs. Prior-year tax documents are typically delivered in January, constraining the FAFSA filing timeline to February and later. Beginning in fall 2016, applicants could submit FAFSAs almost one year prior to their intended enrollment using prior-prior year tax information.

[6]There are six different EFC formulas according to the student's dependency status and whether the student qualifies for a simplified formula. The dependency-based formulas are very similar and mainly differ by the percentages and allowances used. The simplified formula uses a reduced set of financial indicators and is available to families who are eligible to file a 1040A or 1040EZ tax form instead of the longer 1040 form, or who participate in means-tested federal benefits programs and have an adjusted gross income less than a specific amount.

– did not include this information for the cohorts we study. One reason for this omission is that each component of the EFC formula is subject to audit and verification by institutions, who are responsible for compiling aid packages for each admitted applicant.[7]

Financial aid offices at each college where a student is admitted use the Institutional Student Information Record to determine how much need-based aid she can receive based on the reported EFC. Students' need-based and merit-based aid is collectively bound by the cost of attendance. The cost of attendance for a particular college includes tuition and fees, room and board, books and supplies, miscellaneous expenses, and child care or dependent care allowances. There is a maximum and a minimum Pell grant for eligible students and a maximum EFC for Pell eligibility. These criteria vary from year to year according to federal appropriations. Each year, Pell grant eligibility is a sharp function of a particular value of EFC. For instance, year 2006 applicants with EFC equal to $3,851 were ineligible for Pell while applicants with EFC between $3,650 and $3,850 were eligible for a $400 grant. Then for EFC below $3,650, the Pell grant increased one-for-one until the maximum Pell grant of $4,050 was reached for applicants with zero EFC.[8]

Typically, admitted students receive letters in March or April from college financial aid offices specifying the amount of Pell grants and institutional scholarships they are eligible to receive if they enroll. A student's EFC and potential Pell grant is generally constant across colleges,[9] but financial aid packages will differ across institutions according to cost of attendance, college resources, and available state aid. The idea that Pell grants could help students choose between different colleges rests on the non-trivial assumption that students can jointly consider admissions and aid information from multiple schools when deciding where to enroll. The federal aid application timeline offers two ways to do this. When submitting the initial FAFSA, as noted, students can request that their financial details be sent to up to ten schools. After the initial application, students can add or delete schools from this list online, by mail, over the phone, or via the financial aid office of a prospective college. In practice, however, a majority of students list just one school

[7]Current applicants are presented with an estimate of their Pell grant upon completing the online FAFSA. EFC components are still frequently subject to verification, a process which can stretch well into the summer before college begins.

[8]Minimum Pell awards were $400, $890, and $976 for 2007, 2008, and 2009 applicants, respectively, and maximum Pell awards were $4,310, $4,731, and $5,350.

[9]There are rare cases where Pell awards are reduced for exceeding a school's cost of attendance.

on their FAFSA applications.[10]

Could Pell grants lead students to choose more selective institutions? Theoretical expectations are unclear. Pell-eligible students can apply the same grant to any Title IV institution: two-year, four-year, public, private, in-state, or out-of-state. In that sense, Pell grants are conditional transfers that relax households' income constraint for college expenditures and other goods. Ignoring for a moment the institutional response to Pell aid, the grant may affect students' relative preferences for different colleges if demand for college quality is responsive to net price. If the returns to college are greater for those educated at more selective institutions,[11] then basic human capital theory holds that a rational applicant will leverage Pell aid into a more costly, more selective institution.[12]

This simple prediction rests on students having complete information, but in reality they may be uninformed about colleges that make up their choice set, uncertain about their chance of success at a more selective institution, or otherwise unsure about the future benefits of a college education. Moreover, the visage of a rational applicant is more nuanced than one who considers only net price and lifecycle income. Students sort into colleges based on a number of other factors: debt aversion, distance from home (Long, 2004), college amenities (Jacob et al., 2018), and so forth. And the price elasticity of demand for college quality is not readily understood - since the value of the Pell grant is *de jure* equivalent across institutions, Pell eligibility changes the relative price of institutions and could actually lead students to favor less costly, less selective institutions. Consider the Alchian & Allen (1967) theorem, usually applied to a consumer's decision to buy either a high quality or low quality version of the same good. When a fixed cost is added to both goods, the relative price of a high quality good decreases, leading consumers to purchase the higher quality good in spite of the overall price increase. By contrast, uniform Pell grants increase the relative

[10]Across institutions, excluding private for-profit and predominantly certificate-granting colleges, sixty percent of the entering 2006 cohorts sent FAFSA information to just one school (U.S. Department of Education, 2015).

[11]See Kane & Rouse (1995) and Reynolds (2012) for evidence that labor market returns to four-year institutions dominate those for two-year community colleges, Goodman et al. (2017) for evidence that meeting the academic threshold for four-year college admission increases the likelihood of bachelor's degree completion, and Hoekstra (2009) for evidence that gaining admission to an anonymous and selective flagship university significantly increases earnings as a young adult.

[12]See Avery & Hoxby (2004) for an overview of the human capital model specifically in the context of college choice. Rational agents calculate present discounted values for each potential college in their choice set and include the cost of college, grants, scholarships, loans, future earnings, consumption, etc. Then, a rational student chooses the school that maximizes the difference between the present discounted value of benefits and the present discounted value of costs.

price of more costly colleges, perhaps leading some students to favor less selective, less costly institutions. The "free ride" that a \$5,000 Pell grant affords at a community college, for instance, may have more salience than a \$5,000 discount at a four-year university.

Empirical evidence related to our question is less ambiguous than theory. Recent work has shown that gains in families' ability to pay for college – actual or perceived – lead students to select higher quality colleges. Lovenheim & Reynolds (2013) find that rising home equity increases the probability a student attends a high quality institution, and this was especially true for students from low-income families. Hoxby & Turner (2014) report on a randomized controlled trial that provided ACT and SAT test-takers with application fee waivers and information on net price at several different colleges, under the hypothesis that high-achieving, low-income applicants are not fully aware of the aid available to them at more selective institutions. The treatment effectively increased families' perceived ability to pay and led students to enroll in better colleges at a cost of just \$6-15 per student. But for administrative reasons outlined above, the effect of a Pell grant on families' budget constraint may be much less apparent than new housing wealth or an informative mailer.

Expectations from theoretical and empirical frameworks are further clouded when institutional responses are taken in consideration. Colleges publicize the rate of Pell-eligible students they enroll, a signal of economic diversity that may have intrinsic value to institutions, advocacy groups, and alumni. Nevertheless, colleges allocate institutional grants with an approximation of students' ability to pay, a list of the schools each student listed on their FAFSA, as well as full knowledge of applicants' Pell eligibility. The grant may crowd out other sources of aid, yielding little difference in net price across colleges.[13]

The opaque and sharp nature of Pell eligibility as a function of EFC motivates a quasi-experimental analysis of the effect of Pell on college choices. But the timing and delivery of official Pell grant amounts, alongside uncertainty surrounding students' price sensitivity and demand for college quality, leads to ambiguous *a priori* expectations at and below the Pell grant threshold.

[13] Turner (2017) finds evidence that Pell decreases institutional aid 11-20 percent, but that this is more than offset at the eligibility threshold by demand for needy students. Marginally Pell eligible students receive 26 percent *more* institutional aid. If this holds true for our Tennessee sample, then institutional response to Pell eligibility should work to enhance the price effects of the grant.

3 Data and Methods

Data on 2006-2009 Tennessee high school graduates and their FAFSA records are provided by the Tennessee Higher Education Commission, who match students to college enrollment outcomes using the National Student Clearinghouse. We merge information on college selectivity and resources (the ACT scores of incoming classes, instructional expenditures per student, faculty per 100 students, cohort graduation rates,[14] Carnegie class, and published tuition and fees) from the federal Integrated Postsecondary Education Data System (IPEDS). National Student Clearinghouse data on these four cohorts cover observed postsecondary enrollment up to and including the 2009-2010 academic year.[15] For each 2006-2009 graduate, we identify the first instance of a successful FAFSA (excluding dual enrollment) and link that application to college enrollment outcomes the following academic year.[16,17]

From the starting-point sample of 2006-2009 Tennessee high school graduates, we omit 22 percent who do not file a FAFSA before 2011. This sample selection is regrettable but necessary to evaluate the Pell grant's impact on matriculation decisions. Pell eligibility is determined via FAFSA processing, so students who neglect to file an application are automatically ineligible. Moreover, the forcing variable used in regression discontinuity analyses – each student's expected family contribution – is unavailable for students without an application on record. A more subtle data limitation is that we observe Pell eligibility and potential Pell grant amounts, but not take-up. Although results will not necessarily generalize to students who do not file for federal aid or accept entitled Pell grants, findings allow for sharp causal inference regarding financial aid eligibility and

[14] Graduation rates are the share of first-time, full-time degree or certificate-seeking students who complete within 150 percent of normal time.

[15] The National Student Clearinghouse is a non-profit entity whose enrollment data cover, as of this writing, in excess of 98 percent of United States college students. Coverage tends to be narrower, but still over 90 percent, among Tennessee college students due to a preponderance of small religiously-affiliated colleges that do not participate in the Clearinghouse. We have no reason to expect that non-participation rates will affect results and/or vary discontinuously over the Pell eligibility threshold.

[16] This necessarily leads to imbalance across cohorts, in that we allow the 2006 cohort to wait up to four academic years after graduation to file a FAFSA and enroll in college, whereas we observe just one year after high school for 2009 graduates. As we show in the online appendix, results are robust to conditioning on student covariates and cohort fixed effects. Additionally, in an unreported analysis, we find that results are robust to the omission of students whose first FAFSA application is more than one year after high school.

[17] The market for higher education is somewhat concentrated among Tennessee high school graduates, but not so much as to motivate a discrete choice model rather than regression discontinuity identification across a spectrum of college quality. The top five destinations for students in this sample draw 30 percent of college-going seniors, and the Herfindahl-Hirschman Index for all college destinations is 367.

college choices among low-income students who are considering college.

Table 1 lists descriptive statistics for the FAFSA-filing sample as a whole, by subsequent college enrollment (Columns 1-2), as well as for the subset of students whose EFC falls within $3,000 of Pell eligibility (Columns 3-4). Note that 80.5 percent of the bandwidth-restricted sample enrolled in college during the window of time between graduation and 2009-2010. This is considerably higher than the rate of college enrollment for Tennessee high school graduates a whole (63.5 percent among these four cohorts), which is a consequence of inherently higher rates of college-going among successful FAFSA filers. Table 2 lists summary statistics for college outcomes of interest, conditional on enrolling in college at all. We examine a mutually exclusive and exhaustive set of six college sector options, demarcated by control (public or private), state (in Tennessee or not), and level (two-year or four-year). We additionally examine ten measures of college quality and college selectivity, listed and summarized in the bottom portion of Table 2.[18] The tenth measure aggregates five of the others – 25^{th} and 75^{th} ACT percentiles, instructional expenditures, faculty per 100 students, and graduation rates – into a normalized index of college quality.[19]

Column 5 and Column 3 in Table 1 and 2, respectively, list summary statistics for a nationally representative sample of traditional college students who filed for federal aid.[20] Looking first to Columns 4-5 in Table 1, FAFSA-filing, college-going students in Tennessee are similar to enrollees in the NPSAS in terms of Pell eligibility and receipt. Parents in the Tennessee sample typically have higher educational attainment: 48.5 percent of students have at least one college-educated parent, versus 40.8 percent of traditional-aged students in the NPSAS. The Tennessee sample is also more white and more male than the NPSAS.

[18]Note that tuition varies across programs within institutions, particularly in private for-profit colleges. Tuition reported to IPEDS represents what a typical full-time student would pay.

[19]We transform each of the five sub-measures to have mean zero and standard deviation one. The index is the mean of these measures, re-transformed to have a mean equal to zero and standard deviation equal to one within the bandwidth-restricted analytical sample of college-goers.

[20]Statistics for student characteristics in in Table 1 and college sector in Table 2 are for students who applied for federal financial aid and were age 17-21 as first-year undergraduates. These statistics are from the publicly available DataLab tool for the 2008 wave of the NPSAS. Statistics for college quality outcomes are from IPEDS and are for all public and private, not-for-profit four-year and two-year colleges in the U.S. over the 2006-2009 time period, weighted by full-time undergraduate enrollment. While some characteristics of students are not available such as eligibility for specific aid programs in Tennessee, ACT scores, self-reported GPA, and ACT attempts, statistics for college sector, college quality, and several student characteristics are shown. Definitional differences in college sector are noted in footnote b, c, and d in Table 2. In particular, students who applied for federal aid and attend more than one institution (7.7%) are not shown and are reported separately in the NPSAS data.

Looking to Table 2 and comparing Columns 2-3, Tennessee students within $3,000 EFC of Pell eligibility (Column 2) enroll in two-year public colleges, out-of-state colleges, and private non-profit colleges at a similar rate as a nationally representative sample of young undergraduates (Column 3). Traditional-aged Tennesseans are much less apt to enroll in private for-profit colleges than their peers in the NPSAS, and more apt to enroll in public in-state universities. Despite these differences in sectoral preferences, Tennessee graduates enroll in less selective, lower-cost, and lower-resource institutions as measured by ACT scores, instructional spending, net price, in-state tuition, and faculty. Although Tennesseans near the Pell eligibility threshold are almost twice as likely to enroll in a research university, they choose schools with lower graduation rates than the national average (33 percent versus 42 percent in the 2008 NPSAS). These comparisons demonstrate that while Tennessee's prospective college students and federal aid applicants have a typical amount of need alongside socioeconomic advantages in terms of race, gender, and parental education, they tend to sort into less costly and more constrained colleges and universities with weaker graduation outcomes. Financial aid could play a role in improving college choices, but as we show in the sections to follow, that does not appear to be the effect of Pell grants for these students.

Our workhorse specification for regression discontinuity analysis takes the following linear form:

$$Y_{ic} = \alpha + \beta_1 PELL_{ic} + \beta_2 PELL_{ic} * (EFC_{ic} - \bar{E}_c) + \beta_3 (EFC_{ic} - \bar{E}_c) + \epsilon_{ic}, \tag{1}$$

where Y_{ic} is a matriculation or institutional outcome for student i in cohort c, $PELL_{ic}$ is an indicator equal to one for students whose EFC is at or below the Pell eligibility threshold, and $\bar{E}_c$ is the relevant Pell eligbility threshold for cohort c. Robust standard errors are clustered by EFC. We limit the main analysis to students whose nominal EFC falls within $3,000 of the relevant Pell eligibility threshold. This particular bandwidth is similar to but generally wider than optimal bandwidths computed according to Imbens & Kalyanaraman (2012). The online appendix discusses results under wider and narrower bandwidths, optimal bandwidths for each outcome, coarser definitions of the EFC running variable, the inclusion of controls, and other functional forms (quadratic, cubic, fifth-degree polynomial, nonparametric).

Ours is a sharp regression discontinuity analysis, since Pell eligibility rates rise from zero to very nearly one hundred percent at the $EFC_{ic} = \bar{E}_c$ threshold.[21] Figure 1 depicts Pell eligibility relative to the EFC cutoff alongside grantees' potential scholarship.[22] The local average treatment effect (LATE) estimate of Pell eligibility on Y_{ic} is given by β_1 in Equation 1. The LATE applies to compliers, i.e., those who are just eligible for Pell aid below the threshold. Compliance in terms of eligibility is close to universal in this sharp regression discontinuity design, but it is important to note that we can only speculate on the net gain in realized financial aid at and below the threshold. We observe official Pell eligibility in the FAFSA data on hand, but not the amount of the grant students were ultimately awarded, nor do we observe the value of other grants, scholarships, or tuition discounts that coincide with Pell eligibility. The $481 discontinuous rise in potential Pell aid seen in Figure 1 may be prorated for part-time enrollment, reduced by crowd out of institutional aid, or increased with add-on scholarships targeting Pell students.

The standard regression discontinuity identification assumption applies: in the absence of Pell eligibility, potential outcomes would have varied smoothly around the EFC threshold. We indirectly test the identification assumption in three ways. First, we follow McCrary (2008) and test for discontinuities in the density of EFC around the threshold (see Figure 2). A discrete rise in FAFSA records just below the Pell eligibility threshold would be consistent with strategic application behavior that might undermine our identification strategy (for example, if students with stronger college intentions are better able to manipulate their EFC to obtain Pell). Contrary to that notion, we find a significant drop in the density of student financial aid records on the Pell-eligible side of the cutoff.[23] A more aggregated running variable, with EFC measured in $100 bins, varies smoothly over the threshold and rules out anything greater than a 1.7% rise in the height of $100 EFC bins.[24] This implies that applicants are not strategically responding to the publicly available

[21]Estimates of Equation 1 for reported Pell eligibility point to a first-stage discontinuity of between 99 and 100 percent.

[22]Panel I of Figure 1 represents students' actual, reported eligibility, whereas Panel II depicts the maximum grant that students would have been eligible for according to their EFC. Recall we do not observe actual Pell take-up. Pell grants, worth no more than $5,350 for these cohorts, are rarely scaled back for exceeding the cost of attendance constraint, which generally measures in the tens of thousands of dollars.

[23]The log difference in bin height, moving from left to right (eligible to ineligible) is estimated to be 0.214 at the eligibility threshold with a standard error of 0.049. The magnitude of this shift is about 0.20 students per $1 EFC bin, or 2.9%.

[24]The log difference in the height of $100 EFC bins is 0.075 at the Pell cutoff, with a standard error of 0.046. Nevertheless, our preferred specification of Equation 1 uses EFC as we observe it, in $1 increments. Rounding the running variable can bias discontinuity estimates when the slope of the functional form changes at the cutoff (Dong, 2015).

(albeit, complex) EFC formula to gain Pell eligibility, although the unexplained fall in Pell-eligible students does not allay concerns about changes in the composition of students around the eligibility threshold. With this in mind, we estimate discontinuities in pre-college student characteristics like gender, race, ethnicity, and parental education. Results are listed in the top portion of Table 3. We see no indication that students below the Pell threshold were very different from students just above the threshold on these observable measures. We cannot reject the hypothesis that coefficients on $PELL_{ic}$ indicators were jointly zero across Equation 1 estimates for student features ($\chi^2 = 11.65$ with p-value 0.63). Another way to test the fundamental identification assumption is to estimate college enrollment outcomes as a function of students' observable characteristics listed in Table 1 and then examine whether predicted outcomes shift at the threshold. The bottom portion of Table 3 lists findings from that exercise, where we show that expected enrollment outcomes vary smoothly over the Pell eligibility threshold. Figure 3 visualizes the relationships between expected college choices and EFC, which are sloping but continuous for each college sector as well as the normalized college quality index.

As noted in Section 2, marginal Pell eligibility yields a modest grant, which may limit the extent to which students who drive local treatment effects realistically use the Pell to shop for different colleges. Two other factors working against an effect of Pell on college choice include crowd out of institutional aid and opaque, complex communications about Pell eligibility to students. In Section 4.3, we explore these mechanisms in greater detail. We first assess the effect of larger discontinuities in need-based aid, taking advantage of one grant cycle with a particularly generous grant for marginally Pell-eligible students as well as a different need-based aid award worth up to $4,000. We then explore treatment effect heterogeneity by students' self-reported price sensitivity, as well as campus capacity to modify institutional aid. Finally, we quantify causal discontinuities at a simplified threshold of maximum Pell grant eligibility. Results tend to rule out grant size and institutional crowding as factors muting the effect of Pell eligibility on college choices, weakly signifying complexity and delay in the application process as a plausible factor in student decisions.

We wish to examine the effects of Pell grants on students more removed from the eligibility cutoff, and not just for the sake of generalizing local regression discontinuity results. Student aid eligibility and the generosity of Pell grants change from one year to the next, such that marginally

Pell-eligible first-year students do not receive significantly more aid as second-year students or upperclassmen. Focusing on the 2007 cohort of applicants, when we estimate Equation 1 for cumulative potential Pell aid including 2007 and subsequent years, we cannot reject the hypothesis that each $1 rise in Pell grants at the 2007 cutoff increases total undergraduate aid by exactly $1 ($\hat{\beta}_1$ is 1.04, 0.88, and 0.12, respectively, for 2008, 2009, and 2010, and confidence intervals include 1.0). This is readily observed in Figure 4. The contemporaneous aid discontinuity in 2007 is discernible, but there is no level shift of cumulative aid in later years. Inframarginal Pell-eligible students, however, collect more aid in their first year, and the slope of cumulative aid with respect to initial EFC grows steeper with each year. Needier students to the left of the eligibility cutoff may be more affected by Pell if they have a better sense of their current and future financial aid entitlements.

A number of methods have been pursued to explore causal effects away from a regression discontinuity threshold.[25] The best available method for inframarginal analysis in this setting is covariate-based matching introduced by Angrist & Rokkanen (2015), where counterfactual outcomes are extrapolated from one side of the threshold to the other based on observables other than the running variable. Our identifying assumption is that in the absence of Pell, outcomes would be mean-independent of $EFC_{ic} - \bar{E}_c$ when conditioned on a set of X_{ic} student variables: $\mathbb{E}[Y_{ic}^{(j)}|EFC_{ic} - \bar{E}_c, X_{ic}] = \mathbb{E}[Y_{ic}^{(j)}|X_{ic}]; j = 0, 1$, where $j = \mathbf{1}(EFC_{ic} - \bar{E}_c \leq 0)$ indexes the Pell eligibility treatment and X_{ic} represents a set of observed student features. We also require an assumption of common support: $0 < P[PELL_{ic} = 1|X_{ic}] < 1$. As shown in the online appendix, predicted Pell eligibility has broad overlap across Pell-eligible and ineligible students.

The conditional independence assumption implies that the relationship between observable student features and college choices is the same on one side of the Pell eligibility threshold as the other. We test the plausibility of a bounded version of conditional independence using the following specification, applied separately to eligible and ineligible students within $3,000 in EFC

[25] See Dong & Lewbel (2015) and Card et al. (2015) for two leading examples. Also see the online appendix where we explore regression kink identification in this setting. Regression kink results are vulnerable to functional form choices, but they nevertheless support our overarching conclusion that the effect of Pell grants on student sorting among colleges is small at best.

from the cutoff:[26]

$$Y_{ic} = \alpha + \pi(EFC_{ic} - \bar{E}_c) + X_{ic}\gamma + \varepsilon \tag{2}$$

A parsimonious set of X_{ic} observables describing student i are used to model college enrollment choices. We include in X_{ic} measures of demographics (gender, Caucasian race), families' ability to pay (the log of real adjusted gross income), parental education (binary indicators for mothers' college education and fathers' college education), and student ability and commitment to college (first ACT composite score, the number of ACT attempts, indicators for missing ACT data).[27]

If the running variable $EFC_{ic} - \bar{E}_c$ is an insignificant determinant of enrollment conditional on X_{ic} on one side of the threshold, we can argue that $\hat{Y_{ic}}$ can be used to form counterfactual estimates on the other side. As we show in Table A5 of the online appendix, π estimates from Equation 2 are generally small and insignificant in predicting college sector and college quality outcomes for ineligible students. Thus, we use fitted predictions of ineligible student outcomes on the right of the minimum Pell EFC cutoff to extrapolate counterfactual outcomes for eligible students to the left of the cutoff. Also in online appendix Table A5, however, we show that several Equation 2 estimates of π are large and statistically significant for eligible students. Increasingly larger Pell grants may affect college choices – indeed, that idea is the central hypothesis of this section – but this kinked treatment partially invalidates the conditional independence assumption.[28] We cannot confidently map counterfactual outcomes for ineligible students from fitted predictions of eligible students since the latter may have been affected by Pell grants. With this in mind, we focus on treatment-on-the-treated effect estimates where the conditional independence assumption is on firmer footing.

Figure 5 provides a visual analysis of the conditional independence assumption for the likelihood of any college enrollment and three college selectivity and quality measures. To generate these figures we estimate Equation 2 excluding the running variable and plot residuals (dots) and local linear smoothing estimates (lines) against $EFC_{ic} - \bar{E}_c$. We observe heteroscedasticity further from the Pell eligibility threshold, but no slope between the running variable and the unexplained

[26] We use a \$3,000 bandwidth for the sake of consistency with the regression discontinuity sample, although inframarginal results are similar under somewhat wider bandwidths.

[27] The variables in X_{ic} explain 42 percent of variance in the running variable.

[28] Statistically significant π in Equation 2 means that we cannot explain away the importance of the running variable – a function of income – with other observed features and does not on its own imply a causal effect of incremental Pell aid on college outcomes.

portion of college choices. Regression and visual analysis of the conditional independence assumption lead us to conclude that this set of student features can predict counterfactual outcomes for Pell eligible students. Specifically, for each outcome we estimate Equation 2 for Pell-ineligible students with EFC within $3,000 of minimum Pell eligibility (excluding the EFC running variable from controls) and use parameter estimates to predict outcomes for Pell eligible students within the same bandwidth.[29] Following Kline (2011) and Angrist & Rokkanen (2015) we compute standard errors by bootstrap. Importantly, note that conditional independence results to follow are best interpreted as the effect of inframarginal Pell eligibility and not the elasticity of college choice with respect to additional dollars of Pell aid.

4 Results

4.1 Pell eligibility, college enrollment, and the choice of college sector

Figure 6 summarizes findings for the effect of Pell eligibility on any college enrollment. Point estimates and standard errors for β_1 in Equation 1 are listed above each figure. We find no discernible increase in college-going below the Pell eligibility threshold. Potential Pell awards rise $481 at the threshold, so we would expect to see 1.4-2.9 percentage point gains in college enrollment if the Pell discontinuity in aid was as effective as other financial aid programs that have been reviewed (Deming & Dynarski, 2010; Dynarski & Scott-Clayton, 2013). But the confidence interval for Pell's effect on college enrollment falls well short of that benchmark, ruling out any gain greater than 0.7 percentage points.[30] This finding is consistent across subsamples of students based on gender and race, and as we show in the online appendix, results are robust to several modifications of the Equation 1 specification.

One reason that Pell eligibility might be ineffective at pushing marginal college students to enroll is that for these cohorts, eligibility was communicated to students through a complex application process that stretched throughout most of their senior year of high school, after students had committed to enrolling (or not enrolling) in college. This would also tend to work against Pell as

[29] See Kline (2011) for a formal comparison of this regression-based estimator of counterfactuals to semi-parametric, propensity score estimators.

[30] This also falls short of Pell's effect on enrollment gains for non-traditional adult students, 1.3-1.5 percentage points from $745 in aid (Seftor & Turner, 2002).

a tool for students choosing between different colleges, but in principle applicants have leeway to consider aid packages from multiple schools. With this in mind, we limit the sample to college-going students and estimate Equation 1 for a mutually exclusive and exhaustive set of six college sectors. Results are listed in Table 4 and visualized in Figure 7.

Column 1 of Table 4 lists point estimates and robust standard errors for β_1 from Equation 1, applied to the college sector choices of all college enrollees in the four-cohort sample of Tennessee high school graduates. We find no significant discontinuities in students' enrollment behavior broadly, although there are three marginally significant results for subsamples that are worthy of note. First, males are 0.4 percentage points more likely to enroll in a private for-profit college below the Pell eligibility threshold. The point estimate is small and weakly significant, but large relative to the mean for this outcome (also 0.4 percent) and as we show in the online appendix, generally robust to more flexible specifications. Second, females are less likely to enroll in an in-state four-year college and 1.1 percentage points more likely to enroll in an out-of-state four-year college just below the Pell threshold, relative to students who are marginally ineligible for Pell. These findings are robust across several alternative specifications discussed in the online appendix.

Among the thirty estimates presented in Table 4, we might expect three to fall within the 10 percent level of statistical significance. Even if we consider them to be genuine consequences of Pell eligibility, they do not amount to strong evidence that Pell eligibility helps students shop across college options or enroll in better colleges than they would have otherwise. χ^2 tests fail to reject the hypothesis that discontinuities are jointly equal to zero for the broad sample of students (Column 1), and for subsamples by gender and race (Columns 2-5). Note that the likelihood of enrolling in a four-year public or non-profit university (combining three of the outcomes listed in Table 4) falls by an insignificant 0.6 percentage points with a confidence interval ranging from -3.0 to 1.7. The upper end of that range falls short of the 2.7 percentage point effect of Tennessee's merit-based scholarship on four-year enrollment (Bruce & Carruthers, 2014) and the analogous 2.4 percentage point reduced-form effect of Georgia's SAT admission criteria (Goodman et al., 2017).

We note an important observation from Figure 7 before moving on to results for student decisions in terms of college quality. The slope of some outcomes with respect to the running variable changes noticeably at the threshold in ways that suggest that the elasticity of student responses with respect to the grant *value*, rather than grant eligibility, favors more selective colleges. In particular, enrollment in Tennessee two-year community colleges appears to become less likely for needier students who qualify for larger Pell grants, and enrollment in out-of-state four-year public universities becomes more likely. But based on evidence described in Section 4.4, these rotations are likely due to changes in student composition rather than Pell grants.[31]

4.2 Pell and the quality of college

Next, we examine the effect of Pell eligibility on the quality of college chosen, as proxied by nine institutional characteristics drawn from IPEDS and one summary index: the 25^{th} and 75^{th} percentiles of enrollee ACT scores, per-student instructional expenditures,[32] faculty per 100 students, graduation rates, Carnegie class, tuition and fees for in-state residents, tuition and fees for out-of-state residents, average net price,[33] and lastly, a normalized index of college quality that combines five of these measures. Results are found in Table 5. We see little evidence in Column 1 to suggest that the broad population of Tennessee college-goers systematically sorts across college quality domains in response to Pell eligibility. Almost all of the point estimates in Column 1 of Table 5 are consistent with the idea that students move to higher-quality institutions because of Pell, but none of these estimates are statistically significant at conventional levels. The upper limit of confidence intervals for instructional spending and graduation rates ($341 per student and 1.8 percentage points, respectively) are small relative to the effect of sending prospective students customized information about college costs combined with application fee waivers ($1,418 and 3.1 percentage points, per Hoxby & Turner (2014)).

Columns 2 through 5 of Table 5 lists results by gender and race. For each sample of students, we fail to reject the hypothesis that college quality discontinuities are jointly equal to zero. Some dimensions of male college choices, however, may be sensitive to Pell eligibility. Marginally Pell-eligible males attend institutions with a slightly higher interquartile range of student body ACT

[31] In accordance with Section 4.4, regression kink designs discussed in the online appendix do not detect a robust kink in college sector shares.

[32] Instructional expenditures per student are also available from the Delta Cost Project. The Delta Cost Project database consists of IPEDS financial data for colleges, but the data have been adjusted to account for changes in reporting and accounting standards over time. Results and robustness checks when using instructional expenditures per FTE from Delta Cost are consistent with those when using instructional expenditures directly from IPEDS.

[33] Average net price is for full-time, first-time degree or certificate-seeking undergraduates who received aid from grant or scholarship aid.

scores, by 0.21 composite points at the 25^{th} percentile and 0.31 points at the 75^{th} percentile. These discontinuities are subjectively small, equal to one percent of sample means, or 8-10 percent of sample standard deviations. We also detect weakly significant discontinuities in net price for males, but not for other subsamples. Marginally Pell-eligible males attend colleges with a higher net price, by $262. Of all of the college outcomes we examine in this study, results for the interquartile ACT range of males' college choices are thus far the strongest evidence for quality upgrading at the Pell eligibility threshold. Note, however, that in the online appendix we find no inframarginal evidence that males further from the Pell eligibility threshold attend more ACT-selective colleges.

4.3 Mechanisms

There are three leading explanations for weak effects of Pell on college sorting: institutional capture of Pell aid, limited price response to a small grant at the eligibility threshold, and limited awareness of Pell eligibility due to opaque and delayed communications about federal financial aid. Table 6 reports regression discontinuity findings for particular subsamples and alternative thresholds that shed light on the relative importance of these three candidate mechanisms. Column 1 repeats baseline results from Figure 6, Table 4, and Table 5.

Perhaps the minimum Pell grant – just $400 for 2006 and 2007 cohorts – was too small to elicit a discernible response from prospective students. Column 2 focuses on the 2009 cohort of applicants, who were eligible for a $976 Pell grant at the eligibility cutoff. The magnitude of null point estimates changes relative to the baseline, but not in a consistent way suggesting that larger Pell grants led to quality upgrading or significantly different college choices.

Students taking the ACT answer a variety of survey questions, and Column 3 results rely on one of them as a signal for price sensitivity. Specifically, the Column 3 analysis focuses on students who rank tuition as the most or second-most important factor in choosing a college.[34] We do not see evidence of a differential response among such students.

Below the Pell eligibility threshold, the EFC schedule offers a larger discontinuity in financial aid for some low-income students who enroll in an in-state public or private institution. Tennessee Student Assistance Awards (TSAA) are currently worth $1,000-4,000 (about $2,000 on average),

[34]Other listed factors include college size, location, field of study, gender composition, and sector.

with the largest grants available to students in private Tennessee universities. TSAA eligibility is tied to EFC of $2,100 or less, and unlike Pell awards, the grants are not phased in for successively lower EFC. Passing the $2,100 threshold qualifies *some* students for the TSAA,[35] but on a first-come, first-served basis, in that students who file FAFSAs earlier are given priority. The first-stage effect of the TSAA cutoff on eligibility varies from 31-61 percentage points across the 2006-2009 cohorts. Importantly, eligibility for this sizable grant is communicated via the same channel as Pell. Column 4 reports results of a two-stage least squares analogue of Equation 1 for the TSAA discontinuity, with the indicator $\mathbf{1}(EFC_{ic} \leq 2100)$ serving as the excluded instrument for TSAA eligibility. We detect a marginally significant 1.9 percentage point decline in out-of-state four-year college enrollment attributable to the TSAA (an intended consequence of the policy) and marginally significant declines in college selectivity as reflected in the lower end of the ACT interquartile range. Also note that the statistically insignificant effect of the TSAA on any college enrollment is larger than the analogous effect of Pell and more in accordance with research on other financial aid vehicles (in magnitude if not precision).[36] Alongside imprecise effects of TSAA eligibility on several other college measures, these findings are quite limited evidence of behavioral changes due to the TSAA. Nonetheless, χ^2 tests reject the hypothesis that TSAA grants have no local effect on college choice or quality dimensions, and even modest effects from larger, more targeted awards for slightly earlier filers[37] stand in contrast to Column 1-2 results for minimum Pell grant eligibility of varying size.

Column 5 reports enrollment effects from a different discontinuity inherent to FAFSA processing that simplifies the application itself. Families with adjusted gross income (AGI) falling below a particular threshold are automatically assigned an EFC of zero and thus automatically entitled to the maximum Pell grant. This threshold is $20,000 for the first three cohorts in our sample and

[35]McCrary (2008) density tests indicate that EFC is smoothly distributed over the TSAA threshold (with a log difference in bin height of -0.043 and a standard error of 0.048). Like Pell grants, TSAA grants can be reduced for part-time enrollment, early withdrawal, or exceeding the cost of attendance when combined with other sources of aid.

[36]TSAA results listed in Column 4 are largely robust to alternative specifications (available on request). Since TSAA eligibility threshold falls within our baseline bandwidth in the Pell analyses, a practical reason for examining the potential effect of TSAA eligibility is to assess whether this separate grant contaminates Pell results. Column 4 discontinuities at $2,100 EFC are subjectively small and not likely to sway results at Pell eligibility thresholds of $3,850 - 4,617 EFC.

[37]TSAA-eligible "early" filers likely filed no earlier than February of their senior year of high school due to requirements to use prior-year information from income tax returns.

\$30,000 for the last.[38] The likelihood of having zero EFC rises 60 percentage points at the AGI threshold, and the average Pell grant rises \$747 before counting sector-dependent changes in TSAA grants. For online FAFSA filers, who accounted for the vast majority by 2006, automatic-zero rules can substantially shorten and simplify the application process through skip-logic prompts. The automatic-zero rule should also simplify FAFSA verification for students selected by institutions or the U.S. Department of Education to corroborate application items. We estimate by two-stage least squares the effect of Pell grant aid on college outcomes, using $\mathbf{1}(AGI_{ic} \leq \bar{A}_c)$ as the excluded instrument for Pell awards. Looking across all Column 5 outcomes in Table 6, we easily reject the hypothesis that college choice discontinuities are jointly equal to zero at the automatic zero threshold, and particular outcomes change in ways that suggest a price effect. Each \$1,000 in additional Pell aid arising from the automatic-zero rule raises college enrollment by an insignificant 0.3 percentage points (or as much as 3.1 percentage points at the top of the confidence interval) and leads to significant sorting out of public universities in favor of costlier private universities with less of a research focus and (insignificantly) more instructional resources. Compliers choose colleges with \$360 higher published in-state tuition, a 2.8 percentage point lower likelihood of Carnegie research status, and insignificantly higher rates of instructional spending and faculty per student.[39] But given small, statistically imprecise changes in selectivity (ACT scores) and graduation rates at the automatic-zero threshold, it is not *a priori* clear that affected students are better off.

Table 6 includes two additional outcomes drawn from IPEDS: The ratio of net price to out-of-state tuition and the percent of enrolled students receiving institutional aid (means for these variables are 67 and 31 percent, respectively). If institutions reduced the effectiveness of Pell through endogenous price-setting, the net value of the grant would be larger at colleges with higher values of the net price ratio and lower shares of students with institutional aid. Looking across the five specifications in Table 6, we see no statistically significant or directionally consistent changes in the net price ratio at the Pell eligibility, TSAA, or automatic-zero thresholds. The share of students receiving institutional aid rises at each aid cutoff we examine, but never more

[38]AGI values are smoothly distributed over the automatic-zero threshold. The log difference in bin height is 0.022, with a standard error of 0.033.

[39]The economic magnitudes of college choice discontinuities at the automatic-zero threshold are robust to other specifications, although we lose precision with more flexible controls for AGI or narrower bandwidths. Results are available on request.

than 1.3 percentage points and never with enough precision to rule out no change at all. Under a generous interpretation of confidence intervals, Columns 1-3 suggest that marginally Pell-eligible students sort into colleges with more tuition discounting and more institutional aid, which would be consistent with enhanced rather than captured aid at the threshold.

There are a few headlining inferences to draw from the variety of results and sources of additional financial aid reviewed in Table 6. First, additional aid from minimum Pell grants or Pell processing does not lead to an unambiguous change in the quality of colleges that students choose. Of the 80 coefficients presented in the table, just six are statistically significant at conventional levels, and they do not depict a clear flow of students toward or away from particular kinds of institutions. Second, Pell aid does not lead students to favor colleges that have less control over institutional aid, and presumably, less dexterity to capture Pell aid. Third, larger grants or price sensitivity on their own do not substantially change student behavior relative to baseline, null findings from eligibility for minimum Pell grants (Columns 1-3). And last, additional aid arising from the TSAA or automatic-zero rule appears to affect student choice to a greater degree than minimum Pell eligibility. So of the three candidate mechanisms under consideration, extensions in Table 6 tend to rule out grant size and institutional capture as exclusive reasons for muted effects of Pell eligibility on college choices, weakly pointing to Pell grant opacity, timing, and complexity as a more plausible explanation.

4.4 Treatment effects away from the eligibility threshold

With the notable exceptions of gender-specific findings for college selectivity and subtle signs of sorting at the TSAA and automatic-zero thresholds, regression discontinuity results imply that Pell eligibility and Pell awards have limited bearing on students' demand for college overall and their relative demand across the spectrum of college quality and selectivity. One well-known limitation of regression discontinuity analysis is that inferences have local validity and do not necessarily extend to inframarginal individuals more removed from the treatment threshold. In the current context, this means that we do not know if null results at the Pell cutoff generalize to needier students who qualify for larger grants, who are more likely to qualify for Pell grants in subsequent years, and who may be more attuned to the possibility of Pell support.

With this limitation in mind, we follow a method introduced by Angrist & Rokkanen (2015) and examine treatment effects below the eligibility threshold. As outlined in Section 3, we first focus on Pell-*ineligible* students whose EFC falls within $3,000 of the Pell cutoff and estimate college outcomes as a function of exogenous student characteristics listed in Section 3. We then map parameter estimates to Pell-*eligible* students with EFC up to $3,000 below the threshold. Treatment-on-the-treated effects are taken to be the average difference between observed and predicted outcomes, with standard errors estimated by bootstrap.

Key results are depicted in Figure 8 for any college enrollment, Figure 9 for college sector outcomes, and Figure 10 for college quality outcomes. Circles represent observed student outcomes and "X" markers represent counterfactual estimates, summarized by $200 EFC bin. Treatment effects and standard errors are listed under each figure heading. We find no significant treatment effect on college-going below the Pell cutoff (Figure 8) and no meaningful effect on students' chosen college sector (Figure 9).

Regarding the quality of colleges chosen (Figure 10), sub-threshold treatment effects indicate that Pell-eligible students attend institutions with higher tuition and fees than they would have otherwise, by $240 on out-of-state schedules. Within this range of Pell-eligible students, grants were $2,068 on average. This means that each dollar of Pell aid was potentially offset by 11.6 cents of higher tuition, without considering changes in out-of-pocket costs from institutional grants and in-state allowances. In-state tuition and net price also rise above the counterfactual, but by statistically insignificant amounts. While it appears from Figure 10 that treatment effects for out-of-state tuition grow as EFC falls, we emphasize that 11.6 cents per Pell dollar is an average treatment effect as a share of average Pell aid in this window, and not an elasticity with respect to Pell aid.

A $240 gap in actual versus expected tuition is small on the scale of Pell awards, but it is also small on the scale of typical out-of-state tuition among college-going students in the Pell-eligible sample (over $14,000). Even within one subsector – the in-state set of four-year public universities – the standard deviation of published tuition and fees is nearly ten times greater than $240. For more context, Hoxby & Turner (2014) show that experimental beneficiaries of information on net price at various institutions ultimately enrolled in places where instructional spending was $1,418 greater per student, where all student-related spending was $3,037 greater, and where graduation rates were 3 percentage points higher (their Table 5). Nevertheless, joint hypothesis tests from results depicted in Figures 9 and 10 indicate a subtle shift in where students choose to enroll below the minimum Pell eligibility threshold.[40]

5 Discussion

Our regression discontinuity analysis detects no effect of Pell eligibility on Tennesseans' college enrollment *per se*, which is consistent with earlier work on this topic and difference-in-difference identification strategies (Hansen, 1983; Kane, 1995). We also find little evidence at the eligibility threshold to suggest that students use the Pell eligibility as a tool to shop among colleges. Scattered results in favor of quality upgrading among marginally Pell-eligible students include females' substitution out of state and males' choice of more selective colleges at the threshold, but these results are economically small, sensitive to specification, or statistically imprecise. Even under the most optimistic interpretation of confidence intervals, the effect of Pell grant eligibility on college choice is small relative to the effect of merit aid, college admission criteria, or customized information about the net price of college.

One of our more intriguing findings regards the tuition and fees of Pell-eligible students' selected institutions. By identifying treatment effects below the threshold, we find support for the idea that students sort into more costly colleges as a consequence of successively more generous Pell aid, but by just 11.6 cents per dollar of Pell aid. Relative to students at the eligibility cut-off, inframarginal students stand to gain more Pell aid over time and may have a better sense of financial aid entitlements. And yet, we find limited to negligible effects of Pell eligibility on their college choices. Moreover, higher tuition does not necessarily equate with higher quality, and several other dimensions of college selectivity and quality change very little (such as graduation rates) or not at all (instructional expenditures, Carnegie research status) at and below the eligibility threshold. Complementary methods to identify local kinks in treatment effects, discussed at length in the online appendix, find no robust effect of kinks in the Pell formula on realized tuition.

[40]We easily reject the hypothesis that differences between actual and predicted college characteristics, including sector and quality outcomes, are jointly equal to zero ($\chi 2 = 372$).

It does not appear that price insensitivity to small grants at the Pell eligibility cutoff are concealing larger effects of Pell than what we see. One cohort benefitting from larger minimum Pell grants was not more affected by eligibility, nor were students who listed tuition as one of their top considerations in choosing a college. One remaining explanation for generally null results lies with the way in which Pell eligibility and Pell amounts were announced to students. The same opaque and formulaic eligibility criterion that motivates sharp regression discontinuity analysis may hinder applicants' awareness of the program. Moreover, results from financial aid applications were delivered late in the senior year of high school for these cohorts, when many college plans were already in place.

We find suggestive evidence that a larger grant prioritizing earlier filers, or a simplified rule for the maximum Pell grant, leads to modestly more sorting than Pell eligibility *per se*. The federal financial aid process is changing in ways that simplify the application process and move it up in time. Applicants for 2017-2018 could apply as early as the fall of their senior year of high school, and online applicants now benefit from automatic retrieval of income tax data. It remains to be seen whether these developments will effectively make students aware of their Pell eligibility in a way that is useful for college planning. Final determination of Pell aid still rests with institutions, who are tasked with verifying FAFSA components. What is more clear is that for these cohorts of traditional Tennessee college students, the effect of Pell grant aid on whether and where students enrolled in college fell far short of more salient and more timely changes in families' perceived ability to pay.

References

Alchian, A. A., & Allen, W. R. (1967). *University Economics*. Wadsworth Publishing Company.

Angrist, J., & Rokkanen, M. (2015). Wanna Get Away? Regression Discontinuity Estimation of Exam School Effects Away from the Cutoff. *Journal of the American Statistical Association*, *110*(512), 1331–1344.

Avery, C., & Hoxby, C. M. (2004). Do and Should Financial Aid Packages Affect Students' College Choices? In C. M. Hoxby (Ed.) *College Choices: The Economics of Where to Go, When to Go, and How to Pay for It*. Chicago: University of Chicago Press.

Bettinger, E. (2004). How Financial Aid Affects Persistence. In C. M. Hoxby (Ed.) *College Choices: The Economics of Where to Go, When to Go, and How to Pay for It*. Chicago: University of Chicago Press.

Bettinger, E. P., Long, B. T., Oreopoulos, P., & Sanbonmatsu, L. (2012). The Role of Application Assistance and Information in College Decisions: Results from the H&R Block FAFSA Experiment. *Quarterly Journal of Economics*, *127*(3), 1205 – 1242.

Bruce, D. J., & Carruthers, C. K. (2014). Jackpot? The Impact of Lottery Scholarships on Enrollment in Tennessee. *Journal of Urban Economics*, *81*, 30–44.

Card, D., Lee, D. S., Pei, Z., & Weber, A. (2015). Inference on causal effects in a generalized regression kink design. *Econometrica*, *83*(6), 2453–2483.

Carnevale, A. P., & Van Der Werf, M. (2017). The 20% Solution: Selective Colleges Can Afford to Admit More Pell Grant Recipients. Georgetown University Center on Education and the Workforce.

Cohodes, S., & Goodman, J. (2014). Merit Aid, College Quality, and College Completion: Massachusetts' Adams Scholarship as an In-Kind Subsidy. *American Economic Journal: Economic Policy*, *6*(4), 251–85.

Deming, D., & Dynarski, S. (2010). Into College and Out of Poverty? Policies to Increase the Post-secondary Attainment of the Poor. In P. Levine, & D. Zimmerman (Eds.) *Targeting Investments in Children: Fighting Poverty When Resources Are Limited*. University of Chicago Press.

Denning, J. T., Marx, B. M., & Turner, L. J. (2018). Propelled: The effects of grants on graduation, earnings, and welfare. Working Paper No. 23860, National Bureau of Economic Research, Cambridge, MA.

Dong, Y. (2015). Regression Discontinuity Applications with Rounding Errors in the Running Variable. *Journal of Applied Econometrics*, *30*(3), 422–446.

Dong, Y., & Lewbel, A. (2015). Identifying the Effect of Changing the Policy Threshold in Regression Discontinuity Models. *Review of Economics and Statistics*, *97*(5), 1081–1092.

Dynarski, S., & Scott-Clayton, J. (2008). Complexity and Targeting in Federal Student Aid: A Quantitative Analysis. In J. M. Poterba (Ed.) *Tax Policy and the Economy, Volume 22*. Chicago: The University of Chicago Press.

Dynarski, S., & Scott-Clayton, J. (2013). Financial Aid Policy: Lessons from Research. *The Future of Children*, *23*(1), 67–91.

Dynarski, S., Scott-Clayton, J., & Wiederspan, M. (2013). Simplifying Tax Incentives and Aid for College: Progress and Prospects. *Tax Policy and the Economy*, *27*(1), 161–202.

Dynarski, S., & Scott-Clayton, J. E. (2006). The Cost of Complexity in Federal Student Aid: Lessons from Optimal Tax Theory and Behavioral Economics. *National Tax Journal*, *59*(2), 319–356.

Dynarski, S., & Wiederspan, M. (2012). Student Aid Simplification: Looking Back and Looking Ahead. *National Tax Journal*, *65*(1), 211–234.

Goodman, J. (2008). Who Merits Financial Aid? Massachusetts' Adams Scholarship. *Journal of Public Economics*, *92*, 2121–2131.

Goodman, J., Hurwitz, M., & Smith, J. (2017). Access to Four-year Public Colleges and Degree Completion. *Journal of Labor Economics*, *35*(3), 829–867.

Hansen, W. L. (1983). The Impact of Student Financial Aid on Access. In J. Froomkin (Ed.) *The Crises in Higher Education*. New York: Academy of Political Science.

Hoekstra, M. (2009). The Effect of Attending a Flagship State Univeristy on Earnings: A Regression Discontinuity Approach. *Review of Economics and Statistics*, *91*, 717–724.

Hoxby, C., & Turner, S. (2014). Expanding College Opportunities for Low-Income, High-Achieving Students. Stanford Institute for Economic Policy Research Discussion Paper No. 12-014.

Imbens, G., & Kalyanaraman, K. (2012). Optimal Bandwidth Choice for the Regression Discontinuity Estimator. *Review of Economic Studies*, *20*, 1–27.

Jacob, B., McCall, B., & Stange, K. M. (2018). College as Country Club: Do Colleges Cater to Students' Preferences for Consumption? *Journal of Labor Economics*, *36*(2), 309–348.

Kane, T. J. (1995). Rising Public College Tuition and College Entry: How Well Do Public Subsidies Promote Access to College? Working Paper No. 5164, National Bureau of Economic Research, Cambridge, MA.

Kane, T. J., & Rouse, C. E. (1995). Labor-Market Returns to Two- and Four-Year College. *American Economic Review*, *85*(3), 600 – 614.

Kline, P. (2011). Oaxaca-Blinder as a Reweighting Estimator. *American Economic Review*, *101*(3), 532 – 537.

Long, B. T. (2004). How Have College Decisions Changed over Time? An Application of the Conditional Logistic Choice Model. *Journal of Econometrics*, *121*(1-2), 271 – 296.

Lovenheim, M. F., & Reynolds, C. L. (2013). The Effect of Housing Wealth on College Choice: Evidence from the Housing Boom. *Journal of Human Resources*, *48*(1), 1–35.

Marx, B. M., & Turner, L. J. (2018). Borrowing trouble? Student Loans, the Cost of Borrowing, and Implications for the Effectiveness of Need-based Grant Aid. *American Economic Journal: Applied Economics*, *10*(2), 163–201.

McCrary, J. (2008). Manipulation of the Running Variable in the Regression Discontinuity Design: A Density Test. *Journal of Econometrics*, *142*, 698–714.

Reynolds, C. L. (2012). Where to Attend? Estimating the Effects of Beginning College at a Two-year Institution. *Economics of Education Review*, *31*(4), 345–362.

Rubin, R. B. (2011). The Pell and the Poor: A Regression-Discontinuity Analysis of On-Time College Enrollment. *Research in Higher Education*, *52*(7), 675 – 692.

Scott-Clayton, J., & Schudde, L. (2016). Pell Grants as Performance-Based Aid? An Examination of Satisfactory Academic Progress Requiremetns in the Nation's Largest Need-Based Aid Program. *Research in Higher Education*, *57*(8), 943–967.

Seftor, N. S., & Turner, S. E. (2002). Back to School: Federal Student Aid Policy and Adult College Enrollment. *Journal of Human Resources*, *37*(2), 336 – 352.

Turner, L. (2017). The Economic Incidence of Federal Student Grant Aid. Working paper.

U.S. Department of Education (2007). Summary of Changes for the Application Processing System: 2008-2009. *Washington, D.C: U.S. Department of Education, Federal Student Aid*, (p. 6).

U.S. Department of Education (2012). *2011-2012 Federal Pell Grant Program End-of-Year Report*. Office of Postsecondary Education. Retrieved March 7, 2014, from http://www2.ed.gov/finaid/prof/resources/data/pell-2011-12/pell-eoy-2011-12.pdf.

U.S. Department of Education (2015). College Scorecard Data. https://collegescorecard.ed.gov/.

TABLE 1: Summary statistics by college-going status and bandwidth

	(1)	(2)	(3)	(4)	(5)
	Full sample		Bandwidth-restricted sample		National sample
College-going?	No (20.3%)	Yes (79.7%)	No (19.5%)	Yes (80.5%)	
Pell eligible	0.721	0.436	0.644	0.583	0.547
	(0.449)	(0.496)	(0.479)	(0.493)	
Potential Pell award (thousands)	3.079	1.659	1.414	1.225	1.190
	(2.174)	(2.099)	(1.279)	(1.247)	
Mother has a college education	0.246	0.438	0.272	0.388	0.408[a]
	(0.431)	(0.496)	(0.445)	(0.487)	
Father has a college education	0.143	0.357	0.151	0.265	0.408[a]
	(0.35)	(0.479)	(0.358)	(0.441)	
Eligible for TN HOPE	0.066	0.414	0.101	0.409	
	(0.249)	(0.493)	(0.302)	(0.492)	
Eligible for TN ACCESS	0.005	0.010	0.004	0.010	
	(0.07)	(0.102)	(0.061)	(0.097)	
Eligible for TN GAM	0.003	0.045	0.002	0.025	
	(0.058)	(0.207)	(0.047)	(0.155)	
White, non-Hispanic	0.570	0.642	0.748	0.733	0.548
	(0.479)	(0.434)	(0.442)	(0.439)	
Female	0.614	0.529	0.561	0.474	0.576
	(0.499)	(0.496)	(0.499)	(0.496)	
Best ACT Composite Score	18.868	21.186	18.977	20.775	
	(3.113)	(4.317)	(3.053)	(4.033)	
First ACT Composite Score	18.131	20.089	18.254	19.748	
	(2.902)	(4.183)	(2.875)	(3.961)	
Self-reported high school GPA	3.074	3.244	3.074	3.224	
	(0.451)	(0.516)	(0.458)	(0.52)	
Number of ACT attempts	1.752	2.102	1.755	2.054	
	(0.657)	(1.035)	(0.688)	(1.012)	
N (students)	28,470	111,949	6,852	28,340	

Notes: Authors' calculations. Source data for Columns 1 through 4 describe four cohorts of Tennessee public high school graduates from the classes of 2006-2009. The bandwidth-restricted subsample includes students whose expected family contribution falls within $3,000 (nominal) of the Pell threshold. Column 5 lists national data from the 2008 NPSAS, and percentages are for students who applied for federal financial aid, are first year undergraduate students, and are age 17 to 21. [a]Maternal and paternal education are not reported separately in the NPSAS. Having at least one college-educated parent describes 40.8 percent of the NPSAS sample and 48.5 percent of the Tennessee sample.

TABLE 2: Summary statistics for college enrollees, by bandwidth

	(1) Full sample	(2) Bandwidth-restricted	(3) National sample
College sector			
Enrolled in a public TN two-year college	0.334	0.374	0.383^b
	(0.472)	(0.484)	
Enrolled in a public TN four-year college	0.461	0.442	0.245^c
	(0.499)	(0.497)	
Enrolled in a public out-of-state two-year college	0.014	0.014	0.012
	(0.117)	(0.119)	
Enrolled in a public out-of-state four-year college	0.047	0.038	0.023
	(0.212)	(0.191)	
Enrolled in a private four-year non-profit college	0.135	0.125	0.132
	(0.341)	(0.331)	
Enrolled in a for-profit college	0.006	0.004	0.120^d
	(0.079)	(0.067)	
College quality			
ACT Composite 25th Percentile Score (or SAT equivalent)	19.148	18.847	21.0
	(2.928)	(2.708)	(3.3)
ACT Composite 75th Percentile Score (or SAT equivalent)	24.263	23.952	25.9
	(3.216)	(3.094)	(3.2)
Instructional expenditures per FTE student (thousands)	7.057	6.641	7.472
	(6.156)	(5.812)	(6.900)
Faculty per 100 students	7.115	6.863	7.262
	(4.606)	(4.398)	(10.610)
Graduation rate, total cohort	34.962	33.031	42.3
	(20.082)	(19.314)	(23.8)
Published in-state tuition and fees (thousands)	6.497	6.141	8.293
	(6.080)	(5.772)	(8.929)
Published out-of-state tuition and fees (thousands)	14.633	14.129	13.769
	(4.873)	(4.681)	(8.632)
Net price (thousands)	9.681	9.267	11.223
	(4.323)	(3.992)	(6.413)
"High research" or "Very high research" Carnegie class	0.341	0.306	0.160^e
	(0.474)	(0.461)	
Normalized college quality index^a	0.000	0.000	
	(1.000)	(1.000)	
N (students)	111,949	28,319	

Notes: Authors' calculations. Source data for Columns 1 and 2 describe four cohorts of Tennessee public high school graduates from the classes of 2006-2009. The bandwidth-restricted subsample includes students whose expected family contribution falls within $3,000 (nominal) of the Pell threshold. Column 3 lists national data from the 2008 NPSAS and IPEDS for college sector and college quality outcomes, respectively. NPSAS data are for students who applied for federal financial aid and who are first year undergraduate students 17 to 21 years of age. IPEDS data are for public and private, not-for-profit four-year and two-year institutions over the 2006-2009 academic years, and summary statistics are weighted by undergraduate FTE. ^{a}The normalized college quality index is the mean of five quality measures, each transformed to have mean equal to zero and a standard deviation equal to one: 25th and 75th percentile ACT intake, instructional expenditures per FTE, faculty-student ratio (x100), and graduation rate.^{b}Percentage is for a public, in-state two-year college. ^{c}Percentage is for a public, in-state four-year college. ^{d}Percentages from NPSAS for college sector do not add to one as the following are not shown: a private, not-for-profit less than four-year (0.4%); a public less than two-year institution (0.4%); and students who attended more than one institution (7.7%). We do not observe the sectors where multi-institution students enroll. ^{e}The national sample percentage for Carnegie classification is from the 2008 NPSAS.

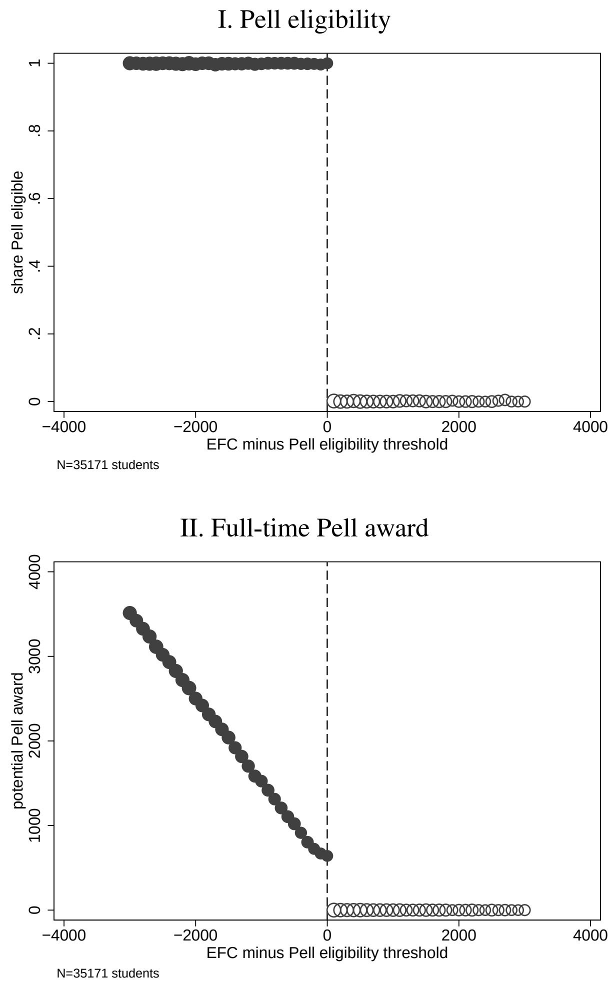

FIGURE 1: Observed Pell eligibility (Panel I) and potential grant amounts (Panel II), by distance from EFC thresholds. Scatter points (dots) represent mean eligibility or grant by distance from Pell eligibility thresholds, where marker size is weighted by the number of students in each $100 EFC bin.

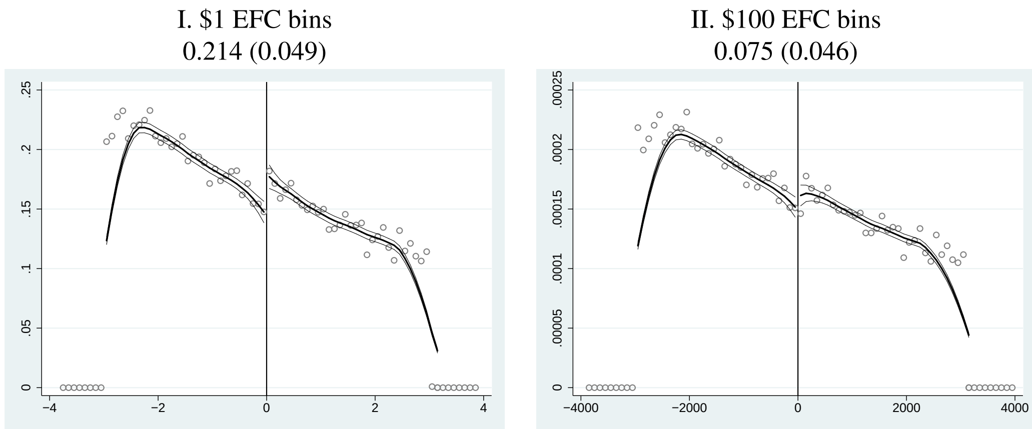

FIGURE 2: Distribution of the running variable around the Pell eligibility threshold. The figure depicts results from a McCrary (2008) density test of EFC within $3,000 of the Pell eligibility threshold. The running variable is expressed in $1 EFC increments in Panel I and $100 EFC increments in Panel II. Log differences in bin height at the threshold are listed above each figure, with standard errors in parentheses. Panel I illustrates a significant fall in the density of student FAFSA records in the Pell-eligible region of EFC. This fall is less discernible in Panel II, which depicts the density of EFC in $100 increments.

TABLE 3: Falsification tests for discontinuities in observables and predicted outcomes

	(1) Coefficient	(2) Robust St. Err.
Student characteristics - joint significance $\chi^2(p)$: 11.72 (0.63)		
Mother has a college education	0.001	(0.010)
Father has a college education	-0.015	(0.010)
Eligible for TN HOPE	-0.011	(0.010)
Eligible for TN ACCESS	-0.001	(0.002)
Eligible for TN GAM	0.002	(0.003)
White, non-Hispanic	0.008	(0.009)
Female	0.004	(0.011)
Best ACT composite score	-0.046	(0.083)
First ACT composite score	-0.025	(0.082)
Self-reported high school GPA	0.006	(0.011)
Number of ACT attempts	-0.007	(0.021)
Predicted college outcomes - joint significance $\chi^2(p)$: 2.09 (0.95)		
Predicted: any college enrollment	-0.006	(0.007)
Predicted: two-year in-state public enrollment	0.002	(0.004)
Predicted: four-year in-state enrollment	-0.006	(0.005)
Predicted: two-year out-of-state public enrollment	0.000	(0.000)
Predicted: four-year out-of-state public enrollment	-0.001	(0.001)
Predicted: private four-year non-profit enrollment	-0.001	(0.002)
Predicted: private for-profit enrollment	-3.9E-04	(3.7E-04)
Predicted: normalized college quality index	0.004	(0.013)

Notes: $N =$ 35,171 students. The table reports estimates of β_1 from Equation 1 applied to student observables (top panel) or predictions of college enrollment outcomes ($\hat{Y}_i$, bottom panel) based on regressions of Y_i against student observables. Above each set of β_1 estimates we report χ^2 statistics for tests of the joint significance of $PELL_{ic}$ coefficients across equations, with p-values in parentheses. Robust standard errors, clustered by EFC, are in parentheses next to each coefficient.
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

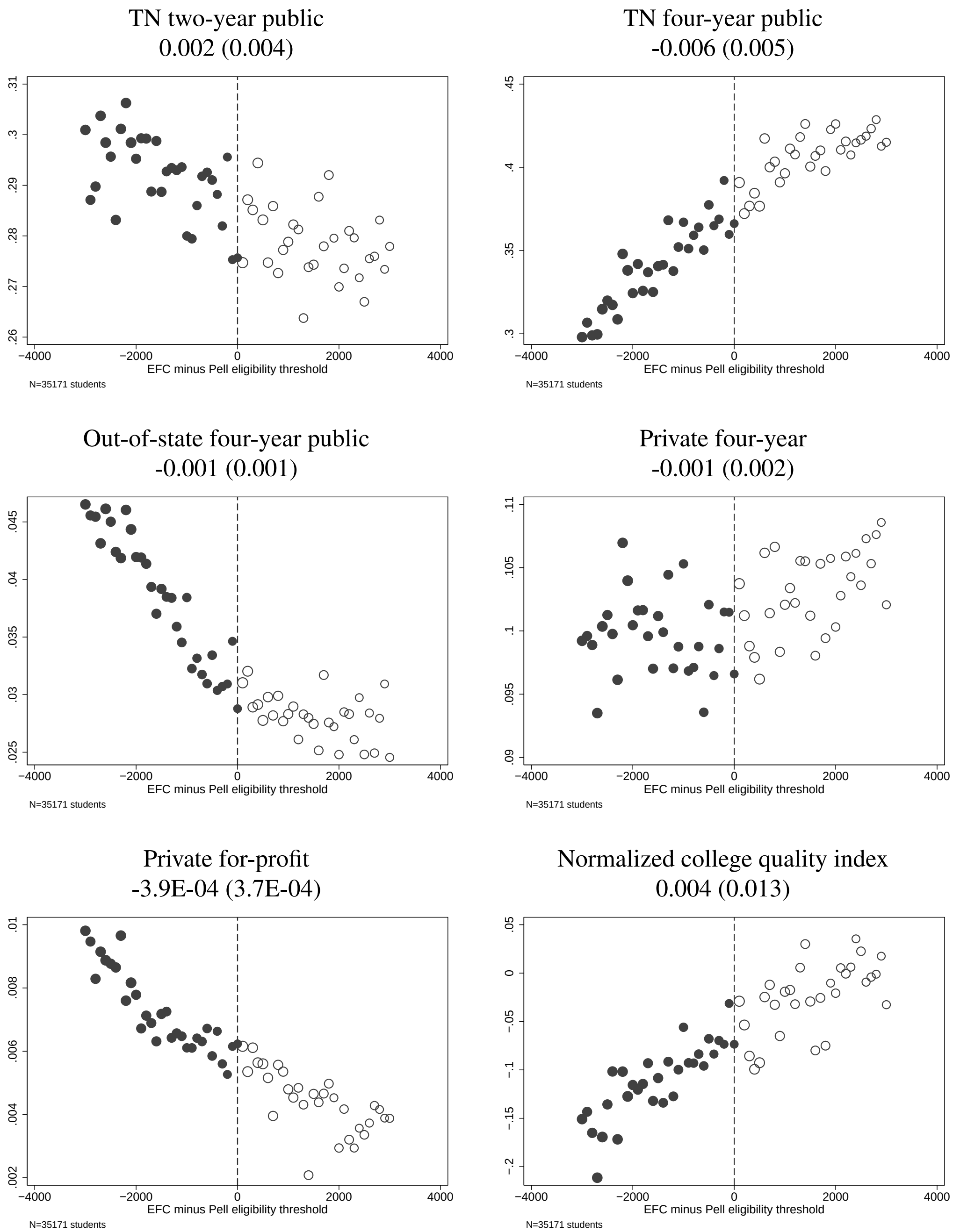

FIGURE 3: Predicted college choices and EFC. Figures plot predicted college outcomes, estimated as a function of students' pre-college characteristics including gender, race, merit aid eligibility, parental education, ACT, high school GPA, and number of ACT sittings. Estimated discontinuities according to Equation 1 are above each figure and also found in Table 3.

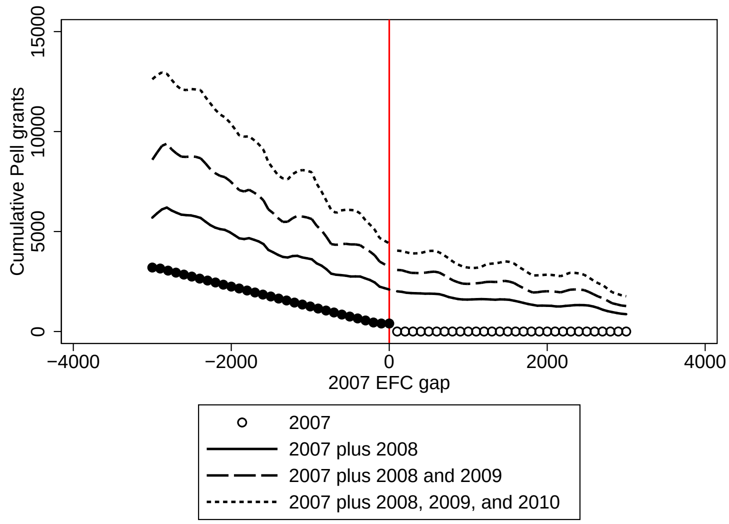

FIGURE 4: Cumulative potential Pell grant awards by first-year EFC. The figure depicts potential Pell grants for 2006-2007 first-time financial aid applicants (circles) alongside mean-smoothing local polynomial estimates of cumulative aid entitlements through later years.

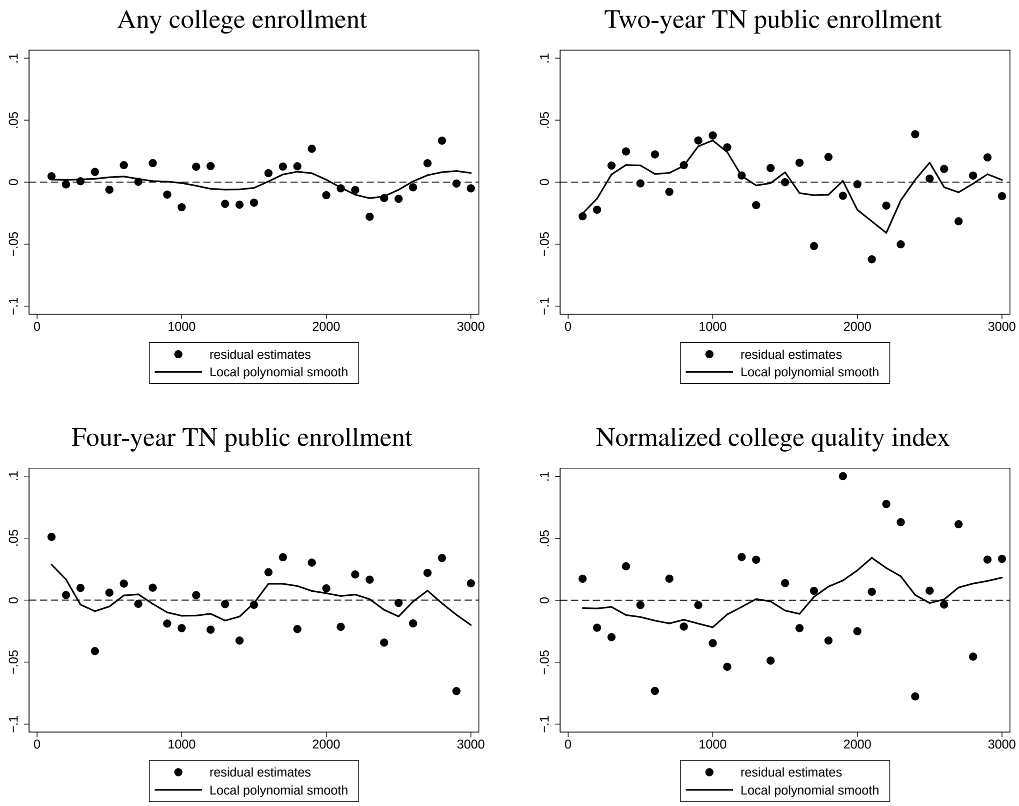

FIGURE 5: The figure depicts residuals and local linear smoothed predictions from regressions of each outcome on student observables used in inframarginal analysis.

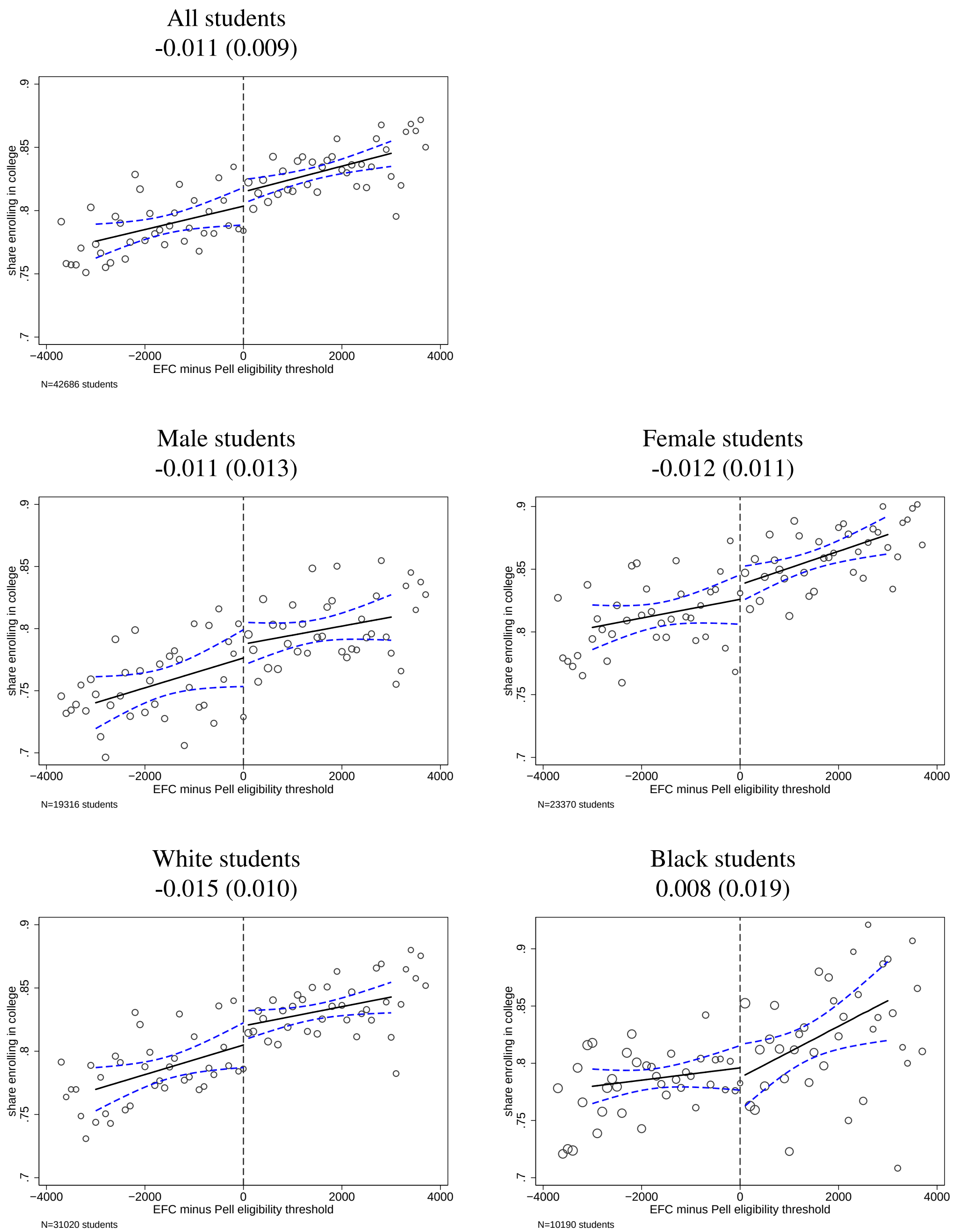

FIGURE 6: Regression discontinuity results for any college enrollment. Scatter points (dots) represent mean college enrollment by distance from Pell eligibility thresholds, with marker size weighted by the number of students in each \$100 EFC bin. Solid lines fit point estimates from Equation 1, with dashed lines bounding 95 percent confidence intervals. Point estimates for β_1 are reported below figure headings, with robust standard errors in parentheses.
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

TABLE 4: Regression discontinuity estimates (Equation 1) for choice of college sector

	(1) All students	(2) Male students	(3) Female students	(4) White students	(5) Black students
Enrolled in a public TN two-year college	0.00226	-0.0232	0.0226	0.00199	0.0209
	(0.0119)	(0.0176)	(0.0157)	(0.0137)	(0.0242)
Enrolled in a public TN four-year college	-0.00920	0.0154	-0.0289*	-0.00576	-0.0227
	(0.0123)	(0.0182)	(0.0164)	(0.0138)	(0.0277)
Enrolled in a public out-of-state two-year college	0.00157	-0.000888	0.00355	0.00364	-0.00724
	(0.00272)	(0.00451)	(0.00336)	(0.00284)	(0.00831)
Enrolled in a public out-of-state four-year college	0.00245	-0.00820	0.0108*	0.00516	-0.00391
	(0.00454)	(0.00685)	(0.00592)	(0.00465)	(0.0131)
Enrolled in a private non-profit four-year college	0.000514	0.0108	-0.00744	-0.00733	0.0122
	(0.00795)	(0.0119)	(0.0108)	(0.00924)	(0.0174)
Enrolled in a private for-profit college	0.00136	0.00359*	-0.000442	0.00201	-0.00270
	(0.00158)	(0.00204)	(0.00227)	(0.00143)	(0.00587)
N (students)	28,319	12,344	15,975	20,943	6,381
χ^2	2.74	8.42	7.77	5.76	2.74
p-value	0.8402	0.2087	0.2553	0.4505	0.8402

Notes: The table reports estimates of β_1 from Equation 1, applied to mutually exclusive and exhaustive college sector outcomes. Robust standard errors, clustered by EFC, are in parentheses below each coefficient. For each column, we report χ^2 statistics and p-values for tests of joint significance of $PELL_{ic}$ coefficients across outcomes.
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

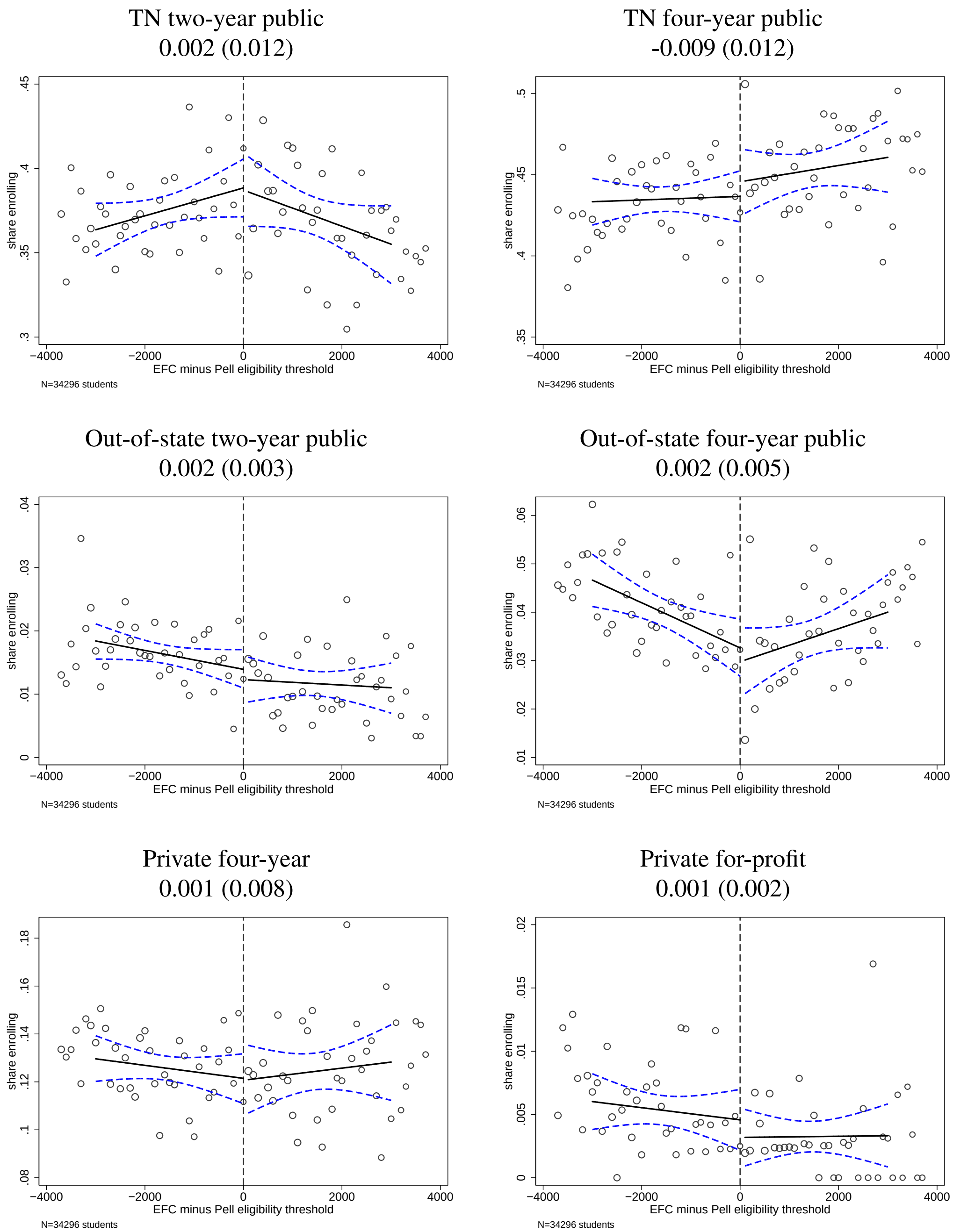

FIGURE 7: Regression discontinuity results for choice of college sector. Scatter points (dots) represent college sector outcomes by distance from Pell eligibility thresholds, with marker size weighted by the number of students in each \$100 EFC bin. Solid lines fit point estimates from Equation 1, with dashed lines bounding 95 percent confidence intervals. Point estimates for β_1 are reported below figure headings, with robust standard errors in parentheses.
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

TABLE 5: Regression discontinuity estimates (Equation 1) for college quality

	(1) All students	(2) Male students	(3) Female students	(4) White students	(5) Black students
ACT 25^{th} percentile (or SAT equivalent)	0.112	0.214**	0.0299	0.0772	0.0290
	(0.0697)	(0.108)	(0.0898)	(0.0745)	(0.183)
ACT 75^{th} percentile (or SAT equivalent)	0.111	0.310**	-0.0474	0.0829	0.0279
	(0.0789)	(0.123)	(0.102)	(0.0873)	(0.200)
Instructional expenditures per FTE student (dollars)	19.17	117.1	-57.31	59.70	-529.2
	(164.3)	(262.3)	(207.9)	(153.3)	(511.7)
Faculty per 100 students	-0.00246	0.0832	-0.0691	-0.00139	-0.235
	(0.121)	(0.192)	(0.154)	(0.115)	(0.365)
Graduation rate	0.783	1.054	0.563	0.560	-0.0719
	(0.499)	(0.753)	(0.648)	(0.565)	(1.120)
In-state tuition and fees (dollars)	153.9	249.7	83.07	67.03	-8.600
	(151.8)	(231.7)	(201.3)	(167.0)	(375.3)
Out-of-state tuition and fees (dollars)	145.0	254.6	58.50	139.0	-195.1
	(121.4)	(183.9)	(158.6)	(130.1)	(307.0)
Net price (dollars)	98.91	262.0*	-26.74	12.94	200.5
	(95.50)	(147.3)	(125.9)	(104.1)	(253.6)
"High research" or "Very high research" Carnegie class	0.00616	0.00748	0.00491	0.00862	-0.0423
	(0.0123)	(0.0183)	(0.0164)	(0.0133)	(0.0298)
Normalized college quality index	0.0293	0.0656	0.000521	0.0221	-0.0230
	(0.0260)	(0.0404)	(0.0335)	(0.0273)	(0.0700)
N (students)	24,646	10,675	13,971	18,310	5,426
χ^2	5.45	9.58	7.78	4.58	9.02
p-value	0.8594	0.4784	0.6500	0.9173	0.5305

Notes: The table reports estimates of β_1 from Equation 1, applied to quality measures of students' chosen college. Robust standard errors, clustered by EFC, are in parentheses below each coefficient. For each column, we report χ^2 statistics and p-values for tests of joint significance of $PELL_{ic}$ coefficients across outcomes.
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

TABLE 6: Regression discontinuity estimates for notable subsamples and larger grant treatments

	(1) Baseline	(2) Class of 2009	(3) Rank tuition high	(4) TSAA discontinuity	(5) Auto-Zero Discontinuity
Treatment	Pell eligibility	Pell eligibility	Pell eligibility	TSAA eligibility	Pell grant (000s)
Any college enrollment	-0.0114	-0.0196	-0.00633	0.0168	0.00410
	(0.00850)	(0.0182)	(0.0105)	(0.0194)	(0.0135)
N (students)	35,171	7,829	17,085	27,192	48,645
Public two-year TN college	0.00226	-0.0148	0.0000345	-0.0120	-0.00962
	(0.0119)	(0.0240)	(0.0163)	(0.0232)	(0.0131)
Public 4-year TN college	-0.00920	0.0229	-0.00682	0.0188	-0.0223*
	(0.0123)	(0.0242)	(0.0171)	(0.0240)	(0.0130)
Public out-of-state four-year college	0.00245	0.00240	0.00216	-0.0186*	0.00364
	(0.00454)	(0.00880)	(0.00582)	(0.00951)	(0.00537)
Private four-year college	0.000514	-0.0164	0.00251	0.0166	0.0186**
	(0.00795)	(0.0160)	(0.0106)	(0.0160)	(0.00857)
ACT 25^{th} percentile	0.112	0.196	0.0714	-0.231*	0.00412
	(0.0697)	(0.151)	(0.0916)	(0.136)	(0.0870)
ACT 75^{th} percentile	0.111	0.148	0.0716	-0.205	0.0340
	(0.0789)	(0.152)	(0.105)	(0.154)	(0.0986)
Instructional spending per FTE	19.17	-331.4	-93.36	-276.6	100.7
	(164.3)	(310.4)	(190.4)	(306.6)	(164.1)
Faculty per 100 students	-0.00246	-0.309	-0.0308	-0.140	0.158
	(0.121)	(0.223)	(0.139)	(0.236)	(0.124)
Graduation rate	0.783	1.605	0.815	-0.703	0.0851
	(0.499)	(1.040)	(0.646)	(0.943)	(0.584)
In-state tuition and fees	153.9	-212.3	193.9	-191.2	359.5**
	(151.8)	(329.4)	(195.4)	(291.2)	(164.0)
Net price	98.91	16.51	101.1	-173.8	56.90
	(95.50)	(205.4)	(124.7)	(181.1)	(112.2)
Carnegie Very High or High Research	0.00616	0.0293	0.00571	-0.0375	-0.0279**
	(0.0123)	(0.0239)	(0.0165)	(0.0234)	(0.0140)
Normalized college quality index	0.0293	0.0272	0.0189	-0.0150	-0.0401
	(0.0260)	(0.0522)	(0.0326)	(0.0493)	(0.0284)
Ratio: Net price to out-of-state tuition	-0.00676	-1.177	-0.130	1.348	0.405
	(0.526)	(1.207)	(0.700)	(0.988)	(0.608)
% students with institutional aid	0.778	0.586	1.057	1.305	0.553
	(0.666)	(1.483)	(0.876)	(1.246)	(0.749)
N (students)	28,319	6,751	14,790	21,309	36,348
χ^2	17.29	21.81	12.35	376.06	743.32
p-value	0.3669	0.1129	0.7196	0.000	0.000

Notes: The table reports estimates of β_1 from Equation 1 in Columns 1-3, where Column 1 repeats baseline results found in Figure 6, Table 4, and Table 5. Column 2 limits the sample to 2009 graduates, who benefitted from the largest marginal Pell award. Column 3 limits the sample to students who ranked tuition as the first or second most important factor in their college choice. Columns 4-5 contain results from two fuzzy discontinuities: the first for TSAA and the second for automatic-zero EFC at fixed adjusted gross income thresholds. Robust standard errors, clustered by units of the running variable, are in parentheses under each coefficient. For each column, we report χ^2 statistics and p-values for tests of joint significance of $PELL_{ic}$ coefficients across outcomes.

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

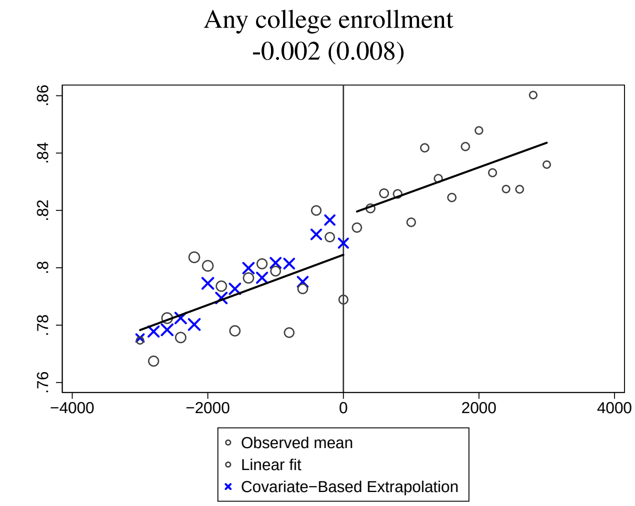

FIGURE 8: Treatment effect estimates for any college enrollment below the eligibility threshold. Scatter points (dots) represent mean college enrollment by distance from Pell eligibility thresholds, with marker size weighted by the number of students in each $200 EFC bin. X-markers represent extrapolated college enrollment as predicted by a regression of outcomes against student observables above the eligibility threshold. Solid lines fit point estimates from Equation 1. The standard error is computed by bootstrap with 1,000 replications of the model for 25 percent random draws. $N = 28{,}028$ Pell-eligible high school graduates.
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

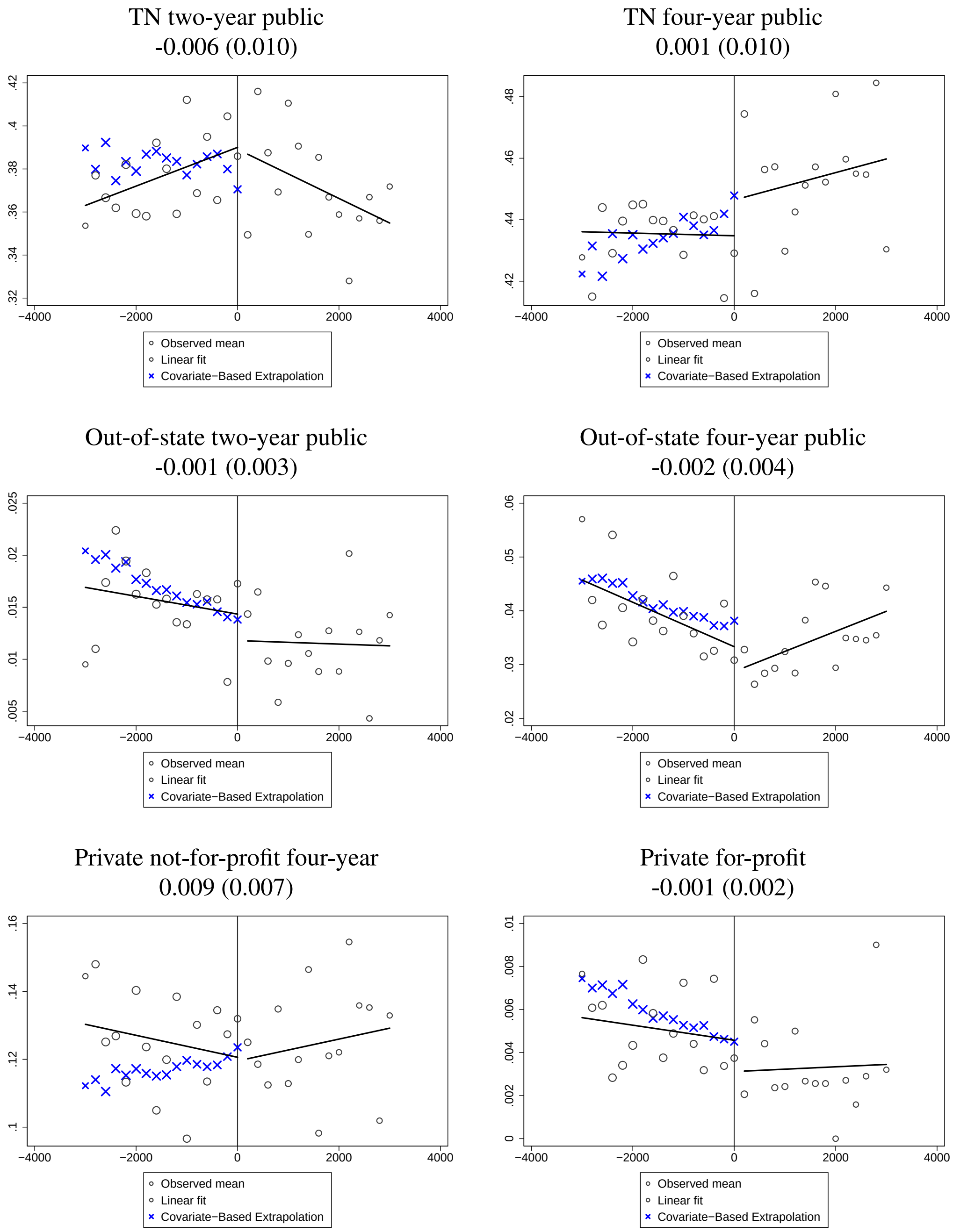

FIGURE 9: Treatment effect estimates for college sector below the eligibility threshold. Scatter points (dots) represent college sector outcomes by distance from Pell eligibility thresholds, with marker size weighted by the number of students in each \$200 EFC bin. X-markers represent extrapolated college enrollment outcomes as predicted by a regression of outcomes against student observables above the eligibility threshold. Solid lines fit point estimates from Equation 1. Point estimates for treatment effects below the threshold are reported below figure headings, with standard errors in parentheses. Standard errors are computed by bootstrap with 1,000 replications of the model for 25 percent random draws. $N = 15{,}855$ Pell-eligible college-going students.
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

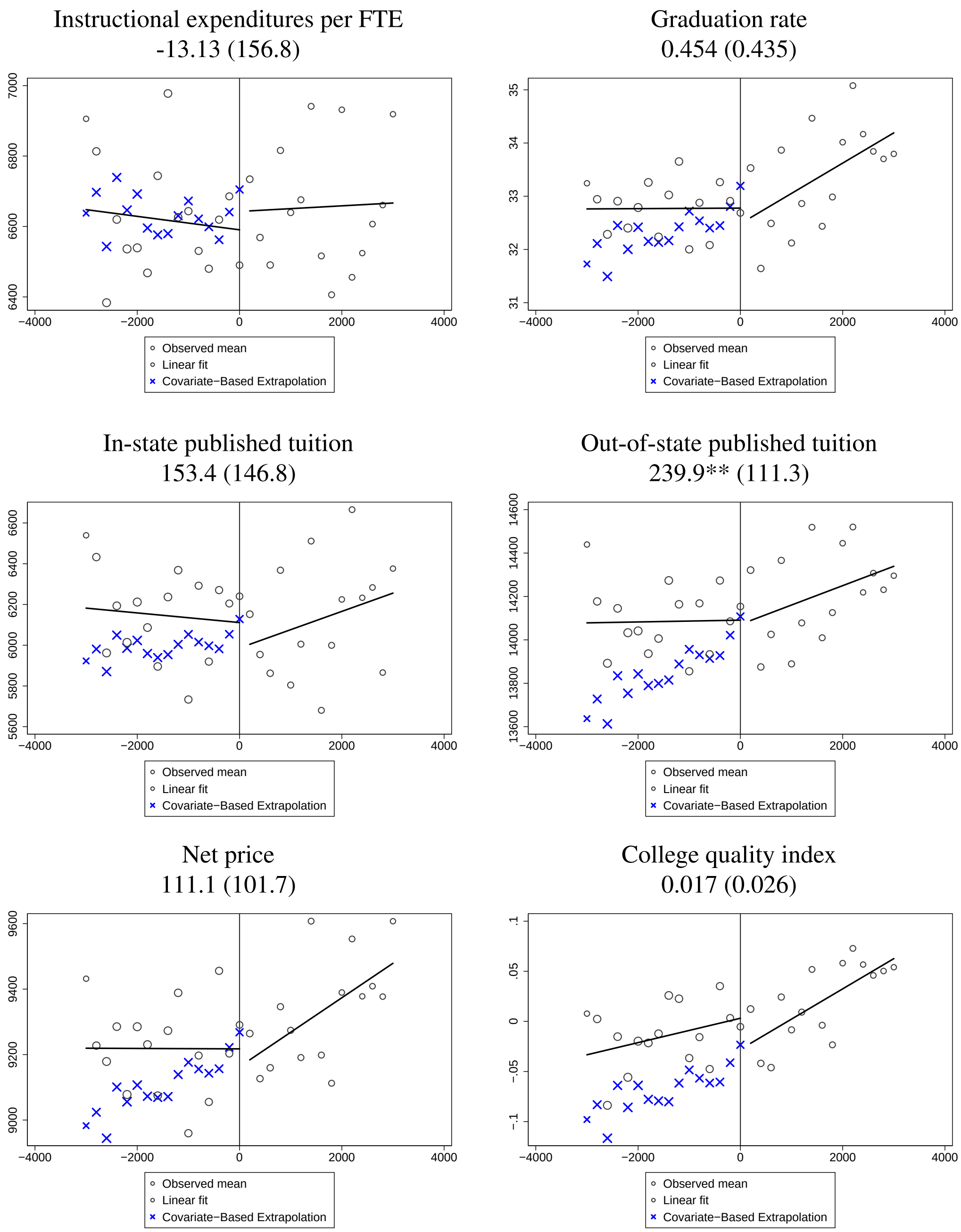

FIGURE 10: Treatment effect estimates for college quality below the eligibility threshold. Scatter points (dots) represent college quality means by distance from Pell eligibility thresholds, with marker size weighted by the number of students in each \$200 EFC bin. X-markers represent extrapolated quality outcomes as predicted by a regression of quality measures against student observables above the eligibility threshold. Solid lines fit point estimates from Equation 1. Point estimates for treatment effects below the threshold are reported below figure headings, with standard errors in parentheses. Standard errors are computed by bootstrap with 1,000 replications of the model for 25 percent random draws. $N = 15{,}855$ Pell-eligible college-going students.

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$