

Jackpot? The Impact of Lottery Scholarships on Enrollment and Earnings in Tennessee

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Abstract

Tennessee has collected over \$2.0 billion in lottery revenues for postsecondary student scholarships, the vast majority of which has funded the HOPE scholarship. For students whose ACT is very close to the HOPE threshold, we find that the scholarship significantly increases college-going, induces substitution away from two-year community colleges in favor of four-year institutions, and reduces students' earnings while enrolled, but has no measurable impact on progression through college. By contrast, difference-in-difference analysis indicates that HOPE increases college persistence among higher-ability students.

JEL: I22, I23, H75, J22

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The relative return to a college degree has risen steeply since the early 1980s. Earnings for college graduates have remained constant in real terms, but the value of a high school degree has fallen considerably (Deming & Dynarski (2009); Levy & Murnane (1992)). In 2005, typical male high school graduates earned \$31,842 nominally, just \$12,492 higher than the federal poverty limit for a family of four.¹ Thus, a college degree is increasingly important for middle-class financial security. The public sector has a long history of subsidizing public postsecondary education, but in light of this growing wage premium, some states have implemented broad-based scholarship programs to reduce or eliminate the direct costs of going to college.² Many of these programs, funded by state lotteries, act like conditional cash transfers to eligible students. Accordingly, we expect state-funded scholarships to increase the likelihood of enrolling in college, to increase persistence through college, to increase the likelihood of degree receipt, and possibly, to increase future earnings. We test whether some of these expectations were realized in Tennessee, where the state lottery has collected over \$2.0 billion for in-state college scholarships since 2004, the vast majority of which has funded the HOPE scholarship. We use regression discontinuity methods to exploit quasi-experimental variation in HOPE eligibility determined by ACT scores, and subsequently, to identify local average effects of eligibility or receipt on several measures of college matriculation, progression through college, and earnings during college. We also use difference-in-differences techniques to test the extent to which regression discontinuity results generalize to

¹Deming & Dynarski (2009) reported average male high school graduate earnings from the Current Population Survey. We adjusted for inflation using the Consumer Price Index. Historic federal poverty levels are reported by the U.S. Department of Health and Human Services.

²Additionally, selective private universities have begun to adopt “need-blind” admissions policies and “no loans” tuition grants to expand access to low-income students.

students of higher ability.

Our principal contributions to this area of research are largely due to rich, multi-dimensional data on recipients and to HOPE's unique policy implications. In addition to postsecondary persistence, earnings, and completion, we examine the effect of lottery scholarships on student matriculation outcomes that are new to this literature: in-state versus out-of-state college enrollment, public versus private enrollment, and for-profit versus nonprofit college enrollment. Choosing between these sectors has been shown to have a large impact on degree completion, earnings, and employment.³ Tennessee's HOPE scholarship is unique in that it can be earned by meeting a below-average ACT threshold, regardless of one's high school GPA.⁴ This provides a valuable opportunity to better understand the credit constraints of extra-marginal college prospects in a state where college enrollment and completion rates are well below the national average.⁵ We show that HOPE alters their enrollment behavior in ways that will likely increase lifetime earnings. Additionally, HOPE's impacts on college persistence – if not completion – appear to be significant for infra-marginal students who would have attended a four-year college in the absence of additional funding. Lastly, we make a methodological advance by utilizing students' *first* ACT scores as running variables in a regression discontinuity framework. We show that students manipulate the HOPE eligibility threshold by taking the ACT multiple times. Unlike best-attempt ACT scores,

³See, e.g., [Deming et al. \(2011\)](#) and [Long & Kurlaender \(2008\)](#).

⁴HOPE's generous eligibility criteria may soon change: to avert budgetary shortfalls, the state legislature is debating whether students should be required to meet both GPA and ACT benchmarks ([Cromer, 2011](#)).

⁵In 2008, 22.9 percent of Tennessee residents held at least a bachelor's degree, compared to 27.7 percent nationwide ([U.S. Census Bureau, 2011](#)).

first-attempt scores are smoothly distributed around the HOPE cutoff.

The hypothesis that exogenous scholarships will increase college participation and progression is intuitive but worthy of further thought. In a life-cycle model of education and consumption, scholarships reduce the contemporaneous cost of education, and thus, should induce students to invest more in their education. But the nominal value of HOPE is a small percent of students' lifetime earnings, and if students can borrow against future income, the effect of HOPE should be very small. Nevertheless, we report large effects of HOPE: for instance, passing the ACT threshold increases college-going by 2.2 - 2.5 percentage points and reduces quarterly earnings while enrolled by as much as \$832. Relative to pre-HOPE cohorts, eligible students stayed in college an additional 0.367 semesters and earned proportionately more credits. These findings can be reconciled with the simple life-cycle model by accounting for credit constraints, debt aversion, and students' rate of impatience. [Rothstein & Rouse \(2007\)](#) illustrate the theoretical and empirical effects of debt reduction at one selective university. [Blinder & Weiss \(1976\)](#) incorporate leisure choices into the life-cycle model and show that individuals with high rates of impatience may prefer to delay schooling until after a period of retirement. In the present context, HOPE scholarships reduce the need for debt by covering a significant portion of schooling expenses.⁶ These same mechanisms may pull in extra-marginal enrollees from the ranks of students who would have chosen work or temporary retirement. Conditional on enrollment, more subtle behavioral incentives may be at work as well. A HOPE awardee must meet GPA targets at particular levels of accumulated credit

⁶Initially, HOPE scholarships approached the typical value of in-state tuition and fees at public community colleges and four-year colleges and universities. In recent years, however, rising tuition and fees have far outpaced periodic increases in the HOPE grant.

hours in order to renew her scholarship. If she is myopic, these targets may spotlight a roadmap that improves her performance and extends her stay in college, relative to the counterfactual.

The effect of HOPE on matriculation to particular types of eligible Tennessee institutions (private, two-year public, four-year public) is unclear *a priori*. HOPE may result in a groundswell of new enrollees that increase matriculation rates to all eligible institutions. But with respect to two-year schools, this could be dominated by infra-marginal enrollees substituting away from community colleges in favor of public and private four-year schools as the expected cost of a longer spell in college falls. We find that surpassing the HOPE eligibility threshold significantly increases the likelihood of going to college at all, and among college-going students, decreases the likelihood of attending a two-year school and increases the likelihood of attending a public four-year school.

Conditional on enrolling in an eligible four-year school, we find little evidence that marginal HOPE recipients stay longer in college or improve their chances of earning a bachelor's degree within four years. While enrolled, students allocate their time between school, work, and leisure. Sensibly, a decrease in the direct cost of schooling should reduce a student's necessary earnings, although in the absence of credit constraints, this reduction need not be exclusive to the period when he was enrolled. We find that passing the HOPE threshold reduces college students' earnings by a large share, consistent with credit and cash-flow constraints during college. Of course, treatment effects estimated by regression discontinuity are limited to students with ACT scores very near the eligibility threshold. Difference-in-difference analysis indicates that the HOPE scholarship effectively increases college persistence overall, if not for marginal HOPE scholars. Furthermore, the earnings behavior of higher-ability students was much less sensitive to HOPE awards.

The remainder of our paper is organized into several small sections. The following sec-

tion describes the HOPE scholarship and compares it to lottery-funded postsecondary scholarship programs in other states. Section 2 situates this study within the broader literature on quasi-experimental effects of financial aid in higher education. Section 3 describes the data and outlines our methodology. Section 4 analyzes recent cohorts of Tennessee high school graduates and presents our findings regarding the effect of HOPE scholarships on matriculation decisions - i.e., whether to go out of state, attend a for-profit school, attend a HOPE-eligible school, and so forth. Section 5 focuses on students who attend a four-year public college or university in Tennessee and determines whether a HOPE scholarship affects their progression, likelihood of graduating, as well as employment and earnings during college. Section 6 offers conclusions and caveats.

1. The Tennessee Education Lottery Scholarship Program (TELS)

The TELS program was initiated after a 2002 referendum approved the creation of a state lottery to fund postsecondary scholarships. Eligibility proposals were debated throughout the early part of 2003, and legislation was complete by May of that year. The first recipients of TELS scholarships were entering freshmen in the fall of 2004, as well as sophomores who met the post-enrollment conditions of a one-time grandfather clause.

The bulk of the TELS program funds the Tennessee HOPE Scholarship, which currently provides \$4,000 per year to eligible students attending four-year institutions and \$2,000 per year to students at two-year institutions without on-campus housing.⁷ Students must attain either a 21 on the ACT or an overall weighted high school grade point average of 3.0 in order to be eligible for

⁷In 2004-2005, the first year of the TELS program, the HOPE scholarship was \$3,000 for students at four-year institutions and \$1,500 for students at two-year institutions. These values were increased to \$3,800 (\$1,900) for 2006-2007 and \$4,000 (\$2,000) for 2007-2008 onward.

a HOPE scholarship. To keep their scholarship, students must maintain full-time enrollment and a college GPA of 2.75 after 24 and 48 attempted hours and 3.0 after 72 and 96 attempted hours, up to five years from the date of initial enrollment. HOPE eligibility also requires Tennessee residency for at least one year and enrollment in an approved institution of higher education within sixteen months of high school graduation or completion of a homeschool or GED program.⁸

Early proposals for HOPE scholarships included a sliding scale based on family income and required students to earn a 3.0 high school GPA *and* at least a 19 on the ACT. This resembled the West Virginia PROMISE scholarship's two-pronged eligibility criteria, which requires a 3.0 high school GPA and at least 21 points on the ACT. Ultimately, the Tennessee legislature abandoned the sliding scale in favor of a flat scholarship for all eligible students (with some supplements for low-income students) and implemented an either/or criteria for high school GPA and ACT.⁹ Other states (e.g., Arkansas and Florida) have similar criteria for lottery-funded higher education scholarships. Georgia's HOPE scholarship, by contrast, requires a 3.0 high school GPA with no ACT option. Some scholarship models award all students performing higher than some percentile of their graduating high school class (New Jersey and South Carolina) or award students after they have enrolled in college and exceeded a particular GPA (New Mexico).

While we do not consider them here, several additional TELS programs provide specialized benefits for enrollees at Tennessee Technology Centers, lower-income non-traditional students, foster children, veterans, high school students taking college courses, low-income students whose

⁸Additional criteria and exceptions are described in full at <http://www.tn.gov/collegepays>.

⁹A 19-point ACT criteria applied only to the fall 2004 entering class. Students entering in January 2005 or later were held to a 21-point eligibility criteria.

ACT and GPA fall just short of HOPE criteria,¹⁰ and students scoring above 29 on the ACT and earning at least a 3.75 weighted high school GPA. Additionally, loan forgiveness programs exist to help those who plan to practice medicine or dentistry in underserved areas as well as future math and science teachers. Together, these specialized grants and supplements account for 28 percent of all TELS awardees and 16 percent of expenditures. The remainder is accounted for by HOPE-eligible students in two-year and four-year colleges and universities.

Table I provides annual TELS expenditures on all scholarships, including HOPE, for the recent history of these programs. Momentous expenditure growth during the programs' early years was primarily due to the annual addition of new eligible cohorts, the addition of new scholarship programs, and the expansion of existing scholarship programs via changes in scholarship amounts and eligibility criteria.

2. Related Literature

This study contributes to a growing literature on the effect of financial aid on student outcomes in higher education. Well-defined eligibility criteria for postsecondary awards have motivated

¹⁰HOPE Access grants are available for students with less than \$36,000 in household income, a 2.75-2.99 high school GPA, and an 18-20 ACT. Access grants are 20-30% smaller than HOPE grants and nonrenewable after 24 credit hours. At that point, Access awardees are eligible to receive HOPE if they have earned at least a 2.75 postsecondary GPA. Since the Access ACT criteria lies within our bandwidth, any significant discontinuities at 17.5 ACT points could affect our HOPE estimates. Between 1.6 and 2.3 percent of students in our samples were ever eligible for Access, and in unreported results available on request, our principal findings are robust to narrower bandwidths.

regression-discontinuity analysis since Thistlethwaite and Campbell's (1960) study on how receiving a National Merit Foundation certificate affects students' higher education attitudes and the likelihood that they receive other scholarships. van der Klauuw (2002) illustrates that an anonymous institution's financial aid rules induce significant discontinuities in the amount of aid offered along a proprietary ranking of students, and in turn, induce a higher likelihood of enrollment at those discontinuities. In other settings, quasi-experimental research has repeatedly demonstrated that merit-based scholarships or institutional financial aid significantly increase enrollment (See, e.g., Goodman (2008), Kane (2003), and Linsenmeier et al. (2006)). In a review of these and related studies, Deming & Dynarski (2009) credit transparent financial aid programs as being the most effective at increasing college enrollment and persistence. It is less clear how financial aid affects substitution between different sectors of higher education. Comprehensive data on the matriculation choices of Tennessee high school graduates allow us to infer student preferences for these sectors from their realized enrollment behavior in light of increased financial aid.

After enrollment, the measure of success for financial aid and merit-based scholarships extends to their impact on outcomes in college and beyond. Scott-Clayton's (2011) regression discontinuity analysis, which is similar to our own, indicates that West Virginia's PROMISE scholarship has no local effect on students' persistence or in-school employment, but increases credits earned, grade-point averages, and the likelihood of receiving a bachelor's degree. A pre-post cohort analysis indicates that academic impacts generalize to higher-ability students, who also tended to reduce their earnings in response to PROMISE. Some of these findings stand in contrast to ours, which suggest that Tennessee's marginal HOPE recipients reduce earnings while enrolled and that they are no more likely to earn a timely Bachelor's degree than students who just missed the ACT el-

eligibility threshold. We believe the difference can be reconciled by eligibility criteria that lead to different sources of identifying variation in scholarship receipt. In West Virginia, PROMISE students must meet a GPA and ACT requirement, whereas in Tennessee, HOPE students can meet a GPA or ACT requirement. Exploiting the ACT threshold identifies the effectiveness of scholarships among students for whom the ACT is the deciding factor in scholarship eligibility. In West Virginia, this corresponds to students with at least a 3.0 high school GPA, whereas in Tennessee, compliers are students with less than a 3.0 GPA. It may well be the case that the effectiveness with which higher education scholarships advance students through college or relieve cash flow constraints is non-uniform across the ability spectrum.

[Scott-Clayton \(2011\)](#) also shows that PROMISE recipients are more likely to meet college credit and courseload benchmarks that are tied to scholarship renewal. These findings underscore the behavioral incentives introduced by discrete renewal criteria. [Cornwell et al. \(2005\)](#) show that renewal requirements for Georgia's HOPE scholarship result in strategic course withdrawals and credit reductions among marginal students at one anonymous university.

If students tend to cluster around scholarship renewal criteria while enrolled in college, then it should be no surprise that eligibility criteria induce strategic behavior while students are thinking about applying to college. [Pallais \(2009\)](#) shows that the introduction of HOPE boosted ACT scores among Tennessee high school students, but had no discernible effect on students' self-reported, *ex ante* preferences for in-state versus out-of-state colleges. If students ramp up their ACT preparations or repeat the ACT in response to the HOPE criteria - and if this behavior is non-uniform in the window around the relevant threshold - then the internal validity of a regression discontinuity approach relying on maximum ACT scores is threatened. Students scoring just above the threshold

would not necessarily be equivalent to students scoring just below. This is a particularly acute concern in Tennessee, where the ACT threshold presents a valuable opportunity for students whose high school GPA is well below 3.0. Using McCrary's (2008) density test, we find that the distribution of maximum ACT scores exhibits a sharp break at the HOPE scholarship eligibility threshold, which is symptomatic of worrisome selection bias. We respond to this threat by using students' *first* ACT score as the forcing variable predicting HOPE eligibility. To date, students' history of ACT scores have rarely been available to researchers. Students who selected into treatment by re-taking the ACT in search of a higher score will not affect findings when initial ACT scores are used as our running variable.

3. Data and Methods

Our regression discontinuity analyses draw on four cohorts of Tennessee high school graduates and four cohorts of students in Tennessee's public four-year colleges and universities. We omit HOPE scholars with qualifying high school GPAs from the main analyses but reserve this subsample for robustness exercises.¹¹ First, we identify Tennessee high school completers with ACT records from the graduating classes of 2006 through 2009. We utilize the National Student Clearinghouse to identify college-going students and characterize the schools they attend. We determine if students attend a two-year or four-year public institution in Tennessee, a private institution in Tennessee, an out-of-state nonprofit college, a for-profit college, or no college. With the exception of for-profit colleges, National Clearinghouse fields identify the type of college or university a student attended. We identify for-profit schools by hand-matching the name of each institution

¹¹Final, official high school grade point averages are known for all HOPE recipients, but not for other students.

attended by a Tennessee high school graduate with a list of for-profit institutions in the Integrated Postsecondary Education Data System (IPEDS) database. We then identify HOPE-eligible students using data collected with the Free Application for Federal Student Aid (FAFSA), which we observe for all Tennessee resident applicants. A student’s HOPE eligibility is determined concurrently with FAFSA processing, regardless of whether he ultimately attends an eligible school. The second sample is composed of the 2005-2008 entering cohorts of first-time freshman in Tennessee’s four-year public colleges and universities. We use administrative data maintained by the Tennessee Higher Education Commission to characterize HOPE scholarship receipt, progression through college, and degree receipt. We then merge post-secondary data with quarterly earnings data provided by the state’s Department of Labor and Workforce Development. Descriptive statistics and additional details are provided for each sample in the following two empirical sections.

If scoring at least 20.5 points on the ACT were the only requirement for HOPE eligibility and receipt, we would proceed by estimating the following:

$$Y_i = \alpha + \beta ABOVE_i + f(ACT_i) + \mathbf{X}_i\delta + \epsilon, \quad (1)$$

where Y_i is our outcome of interest (enrolling in an in-state public four-year school, for instance). $ABOVE_i$ is a binary indicator equal to one for students scoring at least 20.5 points on the ACT, $f(ACT_i)$ is a function of the gap between i ’s ACT score and the threshold (results reported below use a third-order polynomial), and \mathbf{X}_i controls for observable student features like gender, race, ethnicity, and cohort. Equation 1 describes the “sharp” regression discontinuity model, which would be appropriate if all students with $ACT_i < 20.5$ are denied a HOPE scholarship, all students with $ACT_i \geq 20.5$ receive one, and if a sufficient amount of noise allow for random variation in ACT scores around the threshold. In that case, the coefficient β would give us an estimate of the

discontinuity in Y_i at the 20.5-point threshold, which would be interpreted as a causal treatment effect of HOPE. However, meeting the ACT threshold for HOPE is not a necessary or sufficient condition of scholarship receipt. The ACT discontinuity is “fuzzy” in that the likelihood of receiving a HOPE scholarship increases significantly - but by much less than 100 percentage points - at 21 points. This is due to the program’s multi-dimensional eligibility criteria described in Section 1. Any discontinuity in Y_i at the threshold is nevertheless interpreted as a causal treatment effect, but scaled by the marginal probability of receiving HOPE at the threshold.

The validity and strength of our regression discontinuity strategy depends on two features of ACT performance in Tennessee: (1) the extent to which ACT scores are deciding factors in HOPE eligibility and take-up, and (2) the absence of problematic manipulation of ACT scores around HOPE thresholds. To gauge the strength of ACT scores as a forcing variable, we first estimate local polynomial regressions for students with composite scores falling in a six-point window around 20.5.

$$HOPE_i = \eta + \gamma ABOVE_i + g(ACT_i) + \mathbf{X}_i\pi + \varepsilon \quad (2)$$

The dependent variable ($HOPE_i$) is a binary indicator of student i ’s HOPE eligibility or take-up, and other variables are defined as in Equation 1. Results for γ , reported in the following two sections, indicate that meeting the 20.5-point ACT threshold is a significant factor in HOPE eligibility and receipt. The connection between ACT scores, HOPE eligibility, and HOPE take-up serves as the foundation for second-stage analyses of the effect of financial aid (either offered or taken) on student matriculation, post-enrollment progression, and earnings while enrolled. Following [Hahn et al. \(2001\)](#) and [Imbens & Lemieux \(2008\)](#), we estimate two-stage least squares models of the

following form:

$$Y_i = \alpha + \theta HOPE_i + f(ACT_i) + \mathbf{X}_i\delta + \nu, \quad (3)$$

where $HOPE_i$ is HOPE eligibility or receipt estimated by Equation 2, with the indicator $ABOVE_i$ serving as the excluded instrument. The coefficient of interest is θ in each analysis, which is interpreted as the effect of gaining financial aid by *just* meeting the ACT threshold. Inference is limited to the subpopulation of compliers whose scholarship receipt is strictly determined by the ACT criteria. Our necessary assumption is that in the absence of HOPE, the relationship between ACT and later outcomes would have been smooth around 20.5 points. With HOPE in place, any discontinuity we observe at that boundary is considered a causal effect of the scholarship. The implications for external validity are severe. Results are local average treatment effects for compliers *at* the 20.5-point threshold. In exchange for sacrificing external validity, we gain considerable confidence in the internal, causal validity of the estimated impact of HOPE on these students' college outcomes.

This confidence is predicated, however, on the absence of excessive ACT manipulation by college-going students. The HOPE scholarship is generous and well-publicized. Eligibility criteria were finalized and widely announced in May of 2003, well before the first payments were made to eligible freshmen in the fall of 2004. Students can manipulate the ACT criteria by ramping up their study efforts prior to taking the test or by re-taking the test until they surpass the HOPE threshold. We find that students in our sample take the ACT twice, on average, and that scores typically rise on second attempts.

We investigate the extent of ACT manipulation using McCrary's (2008) local linear density estimator. This procedure creates an under-smoothed histogram of ACT scores and estimates the

normalized height of each bin using bin midpoints as regressors. The log difference of intercept coefficients at the 20.5 threshold gives us an estimate of the density break at that point. Figure I illustrates local linear density estimates of ACT scores for 2006-2009 high school graduates. Clearly, there is a significant break in the density of maximum ACT scores at the 20.5-point threshold. This suggests that students are manipulating the HOPE criteria in ways that could confound our analysis. Regression discontinuity estimates that fail to acknowledge the break in maximum ACT scores will mistakenly assume that treated compliers whose best effort is 20.5 points are essentially equivalent to untreated students who score just below the threshold and do not receive a scholarship. In reality, HOPE manipulators, and more importantly, the unobserved characteristics that led them to strategize their ACT efforts (e.g., motivation, parental and peer pressure, financial need), will be over-represented among treated compliers. Thus, any significant difference in college outcomes at the threshold would be driven by HOPE receipt as well as these unobserved characteristics.

Jepsen et al. (2010) document a similar break in best-attempt GED test scores around the passing threshold, and like them, we resolve the problem by using students' first test score as the running variable. Figure I illustrates that there is no significant break in first ACT scores at the 20.5 threshold in either sample. This suggests that manipulation is primarily accomplished through repeated trials and not more intense initial study efforts or knowledge about the ACT scoring algorithm. Figure II shows that among college-going high school graduates, HOPE eligibility increases by 15.8 percentage points for students whose first ACT score just meets the 20.5-point threshold. Other samples used throughout this study exhibit similarly stark discontinuities in HOPE treatment. Test manipulators who fail to achieve at least 20.5 points on their first attempt but ultimately suc-

ceed are considered “always takers” since they obtain HOPE in spite of scoring below the threshold on their first attempt. As with other non-compliers, successful manipulators do not contribute to identification of the effect of HOPE on compliers.

Limiting the scope of inference to the subset of first-attempt compliers introduces another concern about the comparability of treated and untreated students at the threshold. In models where students’ first ACT score is the running variable, counterfactual outcomes will be from students whose first attempt is nearly enough to satisfy the HOPE criteria, and whose subsequent attempts are no better. Ignoring the effects of study and test preparation, suppose that student i ’s ACT score on attempt a is $ACT_{ia} \sim N(\mu_i, \sigma)$, where μ_i is his inherent aptitude, mapped to the ACT scale, and σ is assumed to be constant across students. It may be the case that treated students with $ACT_{i1} = 20.5$ draw from a higher distribution than untreated students with $ACT_{j1} = 20.25$, the next-lowest value. Perhaps untreated compliers draw well with their first attempt but never beat it, whereas a treated complier’s first attempt is more reflective of his μ_i . If so, then treated students may just be of higher ability, which calls into question the continuity assumption underlying the RD model. This would be problematic in the present study if the difference in the μ_i distribution among students scoring 20.50 points initially versus 20.25 is larger than the difference between 19.25 and 19.50 students, between 20.5 students and 20.75 students, and so forth. We explore this using mean ACT scores among students who took the exam at least twice to approximate μ_i . Wilcoxon rank-sum tests indicate that the distribution of mean ACT scores among students who first score 20.5 is significantly higher than the distribution of mean scores among students whose first score is 20.25. But we find significant differences between every pair of mean ACT distributions separated by a 0.25-point gap in initial scores, and the 20.5-20.25 difference is not

atypically large.¹² Treated students likely have higher μ_i than untreated students, but not so much higher as to suggest that the 20.5-point HOPE threshold is driving that difference. Any ability-driven difference in outcomes will manifest in robustness checks – described in Sections 4 and 5 – where we test for discontinuities among students who qualify for HOPE with their high school GPA.

Although the ACT eligibility threshold presents a unique opportunity for causal inference, discontinuities due to the threshold may not generalize to students of higher ability. This remains the overarching limitation of regression discontinuity analysis. Therefore, we also present a regression-adjusted comparison of postsecondary outcomes before and after HOPE was implemented. We use enrollment, progression, completion, and earnings data for one pre-HOPE cohort and four post-HOPE cohorts to estimate the generalized impact of the scholarship on student outcomes. Methodological details and results are provided in Section 5.

4. The Impact of HOPE Eligibility on Matriculation Outcomes

The HOPE scholarship is intended to increase access to college overall, but since eligibility is limited to in-state public or private, nonprofit schools, we do not expect to see enrollment gains at out-of-state or private, for-profit schools. Data on four recent cohorts of Tennessee high school graduates affords us the unique opportunity to test for the effect of merit aid on the likelihood of enrollment *per se* as well as categorical likelihoods of enrolling in different sectors and levels of higher education.

We merge data on more than 150,000 Tennessee high school graduates from the classes of

¹²The 20.5-20.25 difference in mean act scores is 0.31 points, similar to the 21.5-21.25 gap (0.29 points).

2006-2009 with their history of ACT scores. We then merge these data with college enrollment details from the National Student Clearinghouse to identify post-secondary schooling decisions for college-going students. Table II lists descriptive statistics for the sample of 46,795 high school graduates scoring within three points of the HOPE threshold, as well as the subset going to any college. Among all high school graduates within the bandwidth, 75.7 percent have some record of college attendance in the Clearinghouse. Only 1.3 percent attend a for-profit college immediately after high school, 10.7 percent matriculate out of state for college, and 5.0 percent attend an in-state private, nonprofit college. A combined 58.8 percent of graduates attend one of Tennessee's public institutions: 26.7 percent enroll in two-year community colleges and 32.1 percent attend in four-year institutions. Students' best ACT score is 0.7 points higher than their first, on average. Males account for less than half of high school graduates and college-going students.

The internal validity of regression discontinuity estimates would be threatened if the HOPE threshold was coincident with discontinuities in student characteristics that should not have been affected by HOPE eligibility: for instance, gender, race, and ethnicity. We estimate Equation 1 for each control variable and threshold discontinuities are listed in the second and fourth columns of Table II. Curiously, the likelihood of being black significantly increases at the HOPE threshold in the sample of high school graduates as well as the subsample of college-going graduates. Figure III illustrates the share of black students by ACT score, and a non-monotonic discontinuity at 20.5 points is evident. We believe it to be spurious and unrelated to the HOPE treatment, because there is no significant discontinuity in the likelihood of being black at the 20.5-point threshold using *best* ACT scores. A student has less control over his first ACT score than his best ACT score, and if there are endogenous testing behaviors on the part of black students, we would expect this

discontinuity to be more pronounced on the index of best ACT scores.

Turning to our results, we first examine the likelihood of enrolling in any college at the HOPE threshold. This outcome is considered on its own because of the nature of acquiring a HOPE scholarship. Students must file a FAFSA to be considered for HOPE. Scholarship eligibility is the binary dependent variable in Equation 2, the first stage of our TSLS design. Not surprisingly, students who opted not to enroll in college are starkly under-represented in the subset of high school graduates who filed a FAFSA. Since students generally know their ACT scores before they begin the FAFSA process, we lose an undetermined share of untreated compliers when we estimate the probability of going to any college by TSLS. Thus, we estimate this outcome by Equation 1, the sharp regression discontinuity model. Equation 1 understates the impact of HOPE on college-going by a factor equal to the inverse probability of obtaining HOPE at 20.5 points. Results are reported in Table III. All estimates control for cohort indicators, so coefficients are interpreted as relative to one's peers. Controlling for gender and/or race and ethnicity has little effect on point estimates. Meeting the HOPE threshold with one's first ACT score increases the overall probability of attending college by 2.2 - 2.5 percentage points overall, but 4.6 - 4.8 percentage points for males. With regards to the likelihood of attending college, females appear unaffected by HOPE.

Contrasting results for males and females may have less to do with treatment effect heterogeneity than *treatment* heterogeneity. Within the sample of high school graduates, males are better suited to be quasi-experimental subjects because their HOPE eligibility is more likely to be contingent on their ACT performance. Figure IV illustrates cumulative distribution functions for students' self-reported high school GPA (which they note at each ACT exam) and first ACT scores for high school graduates in the estimating sample. Males test somewhat better than females, but

females are much better-represented at the HOPE 3.0-GPA threshold. Furthermore, the discontinuity in HOPE eligibility is much sharper for males. TSLS results to follow for other matriculation outcomes show that males increase their chances of HOPE eligibility by twice as much as females at the 20.5-point ACT threshold.

For the sample of college-going Tennessee high school graduates, we estimate Equation 3 by TSLS for each of the matriculation possibilities summarized in Table II. Results are reported in Table IV. HOPE eligibility increases by 16.4 percentage points (but only 10.8 percentage points for females, versus 23.0 for males) at the 20.5-point threshold. Meeting the HOPE threshold has no significant impact on a student's propensity to attend a for-profit college, and out-of-state college, or an in-state, private college. One of the principal objectives of Tennessee's lottery scholarship program broadly, and the HOPE scholarship specifically, is to incentivize talented students to attend college in Tennessee. We find no evidence of students substituting away from out-of-state institutions, but these results may not generalize to students of higher ability. At the 21-point threshold, which is just below average among all ACT test-takers in the state, students may be more attuned to the extra-marginal decisions of attending college at all, or attending a two-year versus four-year school. Indeed, Table IV indicates that meeting the HOPE threshold results in a significantly lower probability of attending a two-year school, and a higher probability of attending a four-year school. Controlling for gender, race, and ethnicity attenuates point estimates somewhat, but even so, the HOPE threshold is associated with at least an 18.4 percentage point decline in community college matriculation and a 17.5 percentage point gain in four-year college matriculation.

Figure V illustrates our findings for each matriculation outcome. The share of students making

each choice, relative to cohort means, is plotted against fitted third-order polynomial functions on either side of the HOPE threshold. Given the fuzziness of our forcing threshold (recall from Figure II that meeting the 20.5-point criteria increase HOPE eligibility by only 15.8 percentage points), we prefer the higher-order polynomial fit to less flexible quadratic and linear functional forms. Discontinuities are visually and statistically weakened by the outcomes of alwaystakers (e.g., students with sub-20.5 initial ACT scores who met the threshold with a later attempt) and nevertakers (such as non-residents or students who matriculated more than sixteen months after their high school graduation), but nevertheless, reduced-form discontinuities are evident for the likelihood of enrolling in any college, a two-year college, or a four-year college.

ACT scores are important factors in a variety of college admission and financial aid decisions, and part of the estimated effect of HOPE may be driven by unobserved scholarship or admission criteria tied to scoring at least 21 on the ACT. We cannot separate the unique effect of HOPE without knowing something about those other criteria, but we can safely assume that unobserved scholarships and thresholds for admission are not exclusive to 21 ACT points. We test for matriculation discontinuities at other ACT thresholds (results are available on request) and find similar substitution patterns at 19 and 23-point ACT thresholds, which may be critical cutoffs for other programs. The HOPE scholarship's multi-dimensional eligibility criteria allow us to assess whether our main results are driven by HOPE or by other, unobserved treatments tied to the same threshold. We use administrative enrollment records on HOPE recipients to test for in-state matriculation discontinuities among college-going students who qualified for HOPE with their high school GPA.¹³

¹³Unfortunately, final high school GPA data are not available for students who matriculated out of state or to a for-profit institution.

For these students, the 20.5-point threshold should only matter to the extent that it affects their applicant profile or eligibility for other scholarships. We utilize Equation 1 – the reduced-form sharp regression discontinuity model – for this exercise since first-stage HOPE eligibility is unity for all GPA-qualifiers. Results are reported in Table V. For ease of comparison, baseline results for the sample of students without HOPE-qualifying GPAs are also estimated by Equation 1 and listed in Table V.¹⁴ Among HOPE’s GPA-qualifiers, the HOPE ACT threshold decreases the likelihood of two-year college enrollment, but with weak statistical significance and half the magnitude of that which is estimated for students without HOPE-eligible GPAs. And unlike students whose ACT is a deciding factor in receiving HOPE, always-takers with higher GPAs are not significantly more likely to attend a four-year school after meeting the 20.5-point ACT threshold.

5. The Impact of HOPE Eligibility on Post-Enrollment Outcomes in Four-Year Schools

To investigate the effect of HOPE on post-enrollment outcomes, we merge administrative data on enrollment, HOPE receipt, and degree receipt for all students entering Tennessee’s public four-year schools between the fall of 2005 and the spring of 2009 with their history of ACT scores and earnings during college. Earnings data, provided by unemployment insurance (UI) records and the state’s Department of Labor and Workforce Development, are available for all UI-covered workers with wages in Tennessee between the third quarter of 2005 and the second quarter of 2010.¹⁵ We use the Consumer Price Index to account for inflation and express all earnings in 2005 dollars.

¹⁴Note that reduced-form results for students without qualifying GPAs are equivalent to the product of IV and first-stage coefficients reported in Table IV

¹⁵The wage data do not include earnings from other states, self-employment earnings, investment income, or earnings from employment in federal agencies or some private agricultural firms.

As in our analysis of matriculation outcomes, we limit the sample to students within the 6-point bandwidth around the HOPE ACT threshold and omit students who received HOPE because of their high school GPA.

Table VI lists descriptive statistics. We examine several indicators of progression and performance in college: enrolling for just one semester, the total number of semesters enrolled, total credit hours accumulated, and full-time enrollment (i.e., at least 12 credit hours) for the first two, four, and six consecutive semesters, conditional on any activity for each duration. For the 2005 entering cohort, we also examine bachelor's degree receipt. Our identification strategy targets students with below-average ACT aptitude, which is made clear by mean student outcomes. Students in the sample enroll for just 4.6 semesters and 54.2 credits, on average, and 9.3 percent drop out after just one semester. Just 7.1 percent of four-year students obtain a bachelor's degree within four years. We emphasize that these outcomes are not representative of the state's postsecondary population as a whole. In addition to college progression and completion, we also examine two variables describing students' employment and earnings during college. Employment while enrolled is common: 82.2 percent of students have some earnings after entering college and before completion, and in-school wages average \$955.7 per quarter. Much like the sample of high school graduates, college students tend to have taken the ACT multiple times, and their best scores are nearly one point higher than their first, on average. Control variables include gender, race/ethnicity, an indicator for spring entrants, and distance from home.¹⁶ With the exception of an innocuous discontinuity in the likelihood of non-white, non-black, non-Hispanic ethnicities,¹⁷ no control vari-

¹⁶Distances are calculated as the number of miles (straight-line, Euclidean) between one's college and permanent zip code.

¹⁷This discontinuity is due to a wide degree of noise in non-white, non-Hispanic shares across

able exhibits a significant discontinuity at the HOPE ACT threshold.

We estimate the effect of HOPE receipt (in contrast to HOPE eligibility in the previous section) on each outcome listed in Table VI. As in Section 4, all estimates control for cohort indicators, and the excluded instrument determining HOPE receipt is a binary indicator equal to one for students whose ACT score is at least 20.5 points. Results are listed in Table VII. In contrast to the TSLS estimates for high school graduates, females' HOPE takeup is *more* affected by the 20.5-point ACT threshold than males' takeup (increasing by 29.3 - 30.6 percentage points versus 23.4 - 21.4 percentage points for males) and control variables have only a modest impact on point estimates. The first eight outcomes in Table VII pertain to students' post-enrollment progression and performance. We find no local impact of HOPE receipt on the likelihood of a one-semester stay in college, on the total number of semesters students were enrolled, or on the total number of credits accumulated (all relative to students' respective cohorts). And even though students must maintain full-time enrollment to renew the full value of HOPE, we find inconsistent evidence that HOPE increases the likelihood of full-time enrollment at key benchmarks. Females who just met the HOPE threshold are more likely to enroll full-time for their first six consecutive semesters (but no more likely to enroll full-time for the first two or four) and males are more likely to be full-time students over their first four (but not the first two or six) consecutive semesters.

We observe the 2005 entering cohort for four full years, and for that cohort, we find that HOPE did not increase the likelihood of earning a bachelor's degree. Given that we find no strong evidence in support of progression gains among HOPE's just-eligible scholarship recipients, it is not altogether surprising that HOPE had no positive impact on degree completion for this cohort. In-

ACT bins, and results are robust to the exclusion of non-white, non-Hispanic students.

terestingly, males were somewhat *less* likely to graduate on time at the HOPE threshold, although point estimates are weakly significant. Students are eligible to renew a HOPE scholarship until five years have passed from the date of their initial enrollment. HOPE scholars, having paid less in out-of-pocket college expenses for at least part of their enrollment, may have been more likely to defer graduation until their fifth year of college. This delay may have been further justified by weak job prospects for college graduates in 2009. Furthermore, five-year graduation rates have historically been much higher than four-year rates for students with ACT scores near the HOPE threshold, and this is especially true for students with lower high school GPAs. The effect of HOPE on degree receipt and post-college earnings remains a fruitful avenue for future research as additional data become available.

Despite having weak or unintended consequences on students' progression and degree receipt, HOPE has a huge impact on students' labor participation and earnings while enrolled.¹⁸ Overall, marginal HOPE awardees are 14.5 - 14.8 percentage points less likely to work while enrolled in college, relative to untreated compliers who just missed the HOPE threshold. This effect on participation is exclusive to females, although HOPE reduces earnings for both genders. HOPE reduces males' quarterly earnings by as little as \$568.0 and reduces females' earnings by as much as \$953.4. These findings are consistent with strong income effects, or similarly, binding cash-flow constraints.

Figure VI illustrates means and third-order polynomial trends for selected post-secondary outcomes. All estimates control for cohort indicators, so the height of each average and fitted value

¹⁸The HOPE scholarship is not contingent on any work-study requirements, nor does it place any restrictions on employment while enrolled.

is interpreted as relative to peers. HOPE's ambiguous effect on progression and completion outcomes is evident in the first four panels of Figure VI, but the last two panels illustrate a sharp drop in labor force participation and earnings at the HOPE threshold.

As a robustness check, we conduct the same falsification test for postsecondary outcomes as we did in Section 4 for matriculation outcomes. In Table VIII, baseline results (unadjusted by the first-stage probability of HOPE receipt) are compared to estimated discontinuities at 20.5 points among students who qualified for HOPE by earning at least a 3.0 high school GPA. The extent to which HOPE's GPA-qualifiers exhibit the same discontinuities as ACT-qualifiers will lend insight to the potential effect of other scholarships and interventions tied to scoring 21 points on the ACT. Interestingly, the irrelevant HOPE threshold is associated with small but significant declines in accumulated credits and full-time enrollment for GPA-qualifiers. We have yet to find an explanation for these phenomena but note that HOPE may be more effective regarding these outcomes than Table VII suggests if the scholarship worked to offset other, unobserved mechanisms affecting students around the 20.5-point threshold. The HOPE ACT threshold reduces the quarterly earnings of GPA-qualifiers by \$65.2, which is suggestive of other scholarships that relieve cash-flow constraints while enrolled. But this \$65.2 discontinuity is a small share of the reduced-form decline in earnings at the HOPE threshold among students for whom the ACT is decisive in their HOPE receipt.

Next, we test the extent to which our main regression discontinuity results generalize to students further from the eligibility threshold. This cohort analysis relies on difference-in-differences intuition, exploiting intertemporal and ACT-driven variance in the dosage of HOPE eligibility. We assemble data on all students entering in 2002-2003, before HOPE, as well as 2005-2006 through

2008-2009.¹⁹ And to mimic HOPE’s requirements for enrollment within sixteen months of high school graduation, we omit students who were older than twenty at the time of their initial enrollment. Data on pre-HOPE cohorts are missing (1) college matriculation details for students who attended institutions other than Tennessee’s public colleges and universities, (2) ACT scores other than the official (and likely highest) score recorded in THEC administrative files, and (3) high school GPA, which was only collected for HOPE recipients after the program was implemented. Thus, this portion of the analysis is limited to post-enrollment outcomes, conditional on enrolling in a four-year public institution in Tennessee. For consistency across cohorts, we collect ACT scores recorded in THEC administrative files for all students, including HOPE era students, and we do not omit students who receive the scholarship by virtue of their high school GPA. We estimate the following:

$$Y_i = \alpha + \gamma_1 POST_i * ABOVE_i + \gamma_2 ABOVE_i + \gamma_3 POST_i + \kappa h(t) + \mathbf{X}_i \varphi + \eta_i, \quad (4)$$

where $ABOVE_i$ is once again an indicator for having an ACT score above 20.5. These scores are likely to have been students’ highest scores, which we have shown to be subject to manipulation, but results are robust to other treatments. $POST_i = 1$ for the HOPE era cohorts entering in 2005-2006 and later, $h(t)$ controls for linear and quadratic time trends, and \mathbf{X}_i variables are defined as before. The coefficient of interest is γ_1 , interpreted as the average change in Y_i among students with ACT scores above 20.5 after HOPE was implemented. Equation 4 is not a strict difference-in-

¹⁹We omit enrollees from two transitional years. Enrollees in 2003-2004 were eligible to receive the scholarship in the following year, provided they met certain post-enrollment performance benchmarks. Fall 2004 enrollees were subject to a lower ACT criteria than spring 2005 and later enrollees.

difference estimator, because some members of $POST_i$ cohort with ACT scores below the HOPE threshold earned the scholarship with their high school GPAs. These exceptions attenuate the estimated impact of HOPE toward zero by misclassifying some treated students.

Estimated values of γ_1 for several post-enrollment outcomes are presented in Table IX alongside sample means.²⁰ In stark contrast to our regression discontinuity findings, we show that a higher dosage of HOPE eligibility meaningfully decreases the likelihood of early exit from college, increases persistence by 0.367 semesters and 6.00 credits, on average, increases full-time enrollment at key renewal benchmarks, but has no discernable impact on labor force participation or earnings while enrolled. Persistence impacts are somewhat stronger for females, and echoing our findings from regression discontinuity analyses, markedly reduced for students within a six-point window around the ACT threshold. This leads us to conclude that HOPE's post-enrollment impacts were stronger for students of higher ability, whose ACT performance was well above 20.5 points.

We also estimate quantile regression analogues to Equation 4 for cumulative credits to better understand heterogeneous responses to the scholarship. Figure VII plots nine quantile coefficients, interpreted as the estimated change in the q^{th} quantile of credits attributable to the scholarship. Results indicate that HOPE widens the distribution of college persistence, as proxied by accumulated

²⁰Note that the estimating sample is larger than it was in earlier post-enrollment exercises. This is because of (1) the addition of one pre-HOPE cohort, (2) the addition of students outside the 6-point window around 20.5 ACT points, and (3) the inability to exclude pre-HOPE students with high school GPAs above 3.0. GPA data are not available for pre-HOPE cohorts, so for consistency, we include all students regardless of high school GPA in estimates of Equation 4.

credits. HOPE lowers the 10th and 20th quantiles, but increases the number of credits tied to the 40th quantile and above. This is consistent with both positive and negative selection into four-year schools as a result of HOPE. Extra-marginal college enrollees may use the scholarship to substitute out of community colleges but then fail to persist in a four-year school for long, pulling the lower tail even lower. Students who would have gone to college in the absence of HOPE may have been induced to stay longer, shifting the conditional mean and upper tail even higher.

Positive selection into capacity-constrained colleges could bias our post-enrollment estimates upward. Echoing Pallais's (2009) findings on *ex ante* preference for in-state schools, the previous section reports no evidence of stronger in-state preferences at the HOPE threshold, although it remains to be seen if the scholarship effectively retained high-achieving students in the state. Following Scott-Clayton (2011), we determine whether our findings are robust to extreme assumptions about HOPE era students in four-year schools: specifically, that a large portion of them turn out to have the highest college GPA among their peers. We re-estimate Equation 4, omitting students enrolling 2005-2006 and later with HOPE-eligible ACT scores whose last observed college GPAs are in the top twenty percentiles of their cohorts. Results are listed in the rightmost column of Table IX. With the exception of credits, persistence coefficients are attenuated in magnitude but still quite large and significant, suggesting that high-ability students who selected into our sample because of HOPE were not largely responsible for those results. Interestingly, the likelihood of timely Bachelor's degree receipt is significantly negative when we omit top-performing students who were treated by HOPE. This is consistent with our regression discontinuity results, reflective of the scholarship's five-year eligibility window, and suggestive of positive selection by students who would have graduated on time with or without HOPE.

6. Conclusions and Caveats

We find robust evidence of ACT manipulation in response to Tennessee's HOPE scholarship, some evidence of positive selection into the state's four-year institutions, as well strong evidence of HOPE's effectiveness in changing postsecondary enrollment, persistence, and employment behavior. ACT manipulation in response to HOPE highlights a considerable threat to internal validity in regression discontinuity analyses where the criteria for treatment is well known and individuals can make multiple attempts to gain treatment. Students who just qualify for a HOPE scholarship by scoring at least 20.5 points on their *first* ACT exam (a threshold which affects HOPE eligibility and take-up but does not appear to be affected by manipulation) are more likely to go to college, tend to substitute away from two-year community colleges in favor of four-year colleges and universities, and earn substantially less while enrolled, relative to students who just fall short of the ACT criteria. Within the limited group of students for whom our regression discontinuity identification strategy matters, HOPE has no effect on college persistence, little measurable impact on full-time enrollment, and no effect on the likelihood of graduating within four years. It remains to be seen if HOPE affects five-year graduation rates, or if the financial freedom afforded by the HOPE scholarship causes some students to substitute away from high-return majors. These issues are the focus on our ongoing research regarding the impact of HOPE.

It bears repeated emphasis that regression discontinuity findings are limited to the small set of compliers at the 20.5-point threshold for whom the first ACT was decisive. We believe this limitation is actually a strength of our study. As part of Tennessee's Race to the Top initiative, the state pledged to increase the number of college-going high school graduates by 19.4% between 2007-2008 and 2014-2015.²¹ The Complete College Tennessee Act of 2010 underscores the state's

²¹See Appendix A-1-4 of Tennessee's Race to the Top Application (January 2010, available at

resolve to improving higher education outcomes. A principle objective of this legislation is to “increase degree production within the state’s capacity to support higher education.”²² Nationwide, a growing wage premium for college graduates has spurred demand-side and supply-side actions to increase access to higher education. The marginal college enrollee likely resembles our study’s marginal HOPE recipient in terms of high school achievement. Here, we have provided evidence that HOPE’s financial incentives increase college-going among these marginal students, if not their persistence through college. HOPE has more of an effect on the intensive margin of college persistence for higher-ability students with ACT scores that are farther from the eligibility threshold. A cohort analysis links a higher dosage of HOPE eligibility to significantly longer stays in college but an uncertain effect on the likelihood of graduating within four years.

Given these results, an important question arises: are scholarships for marginal students or students who fail to earn a degree worth their cost? We show that HOPE increases college enrollment *per se*, induces substitution into four-year colleges and universities, increases persistence among higher-ability students, and reduces earnings while enrolled. Each outcome can be theoretically linked to higher earnings later on.²³ HOPE scholars in our sample of four-year college enrollees <http://www2.ed.gov/programs/racetothetop/phase1-applications/appendixes/tennessee.pdf>

²²The Complete College Act amended TCA 49-7-202(c)(1). The full text of the Act is available at http://tn.gov/moa/documents/master_plan_comm/.

²³A vast number of researchers have sought to identify the returns to schooling under different circumstances or interventions. [Heckman et al. \(2006\)](#) provide a review and critique of methods. [Hoekstra \(2009\)](#) shows that the earnings premium from attending a flagship university (as opposed to a less selective institution) can be as much as 20%, which is suggestive of the returns that may arise from substitution patterns due to HOPE. Finally, [Stinebrickner & Stinebrickner \(2003\)](#) find

tend to keep their scholarship for 2.5 academic years, on average, drawing \$10,000 - \$12,500 in HOPE grants and supplements as of 2009 current award levels. Accordingly, a very small lifetime earnings premium would recover the cost of subsidizing a student who went to college, chose a four-year university, stayed in college longer, and spent less time working while enrolled because of HOPE. It remains to be seen, however, if that earnings premium will be realized, or if general equilibrium dynamics will dampen the labor market's value of marginal students. Furthermore, the impact of HOPE on college enrollment and persistence might be replicated with other interventions that relieve cash-flow constraints, like low-interest or forgivable loans with incentives for progression and degree completion. Lastly, the pecuniary returns to HOPE do not fully speak to the normative value of transferring income from lottery ticket buyers to college students. General equilibrium issues are important components of efficacious financial aid policy but well beyond the scope of this study. As to HOPE's first-order effectiveness, we find that the scholarship promotes extra-marginal college enrollment and substitution among below-average students, as well as substantially greater college progression among higher-ability students.

that additional hours of work reduce academic performance in college.

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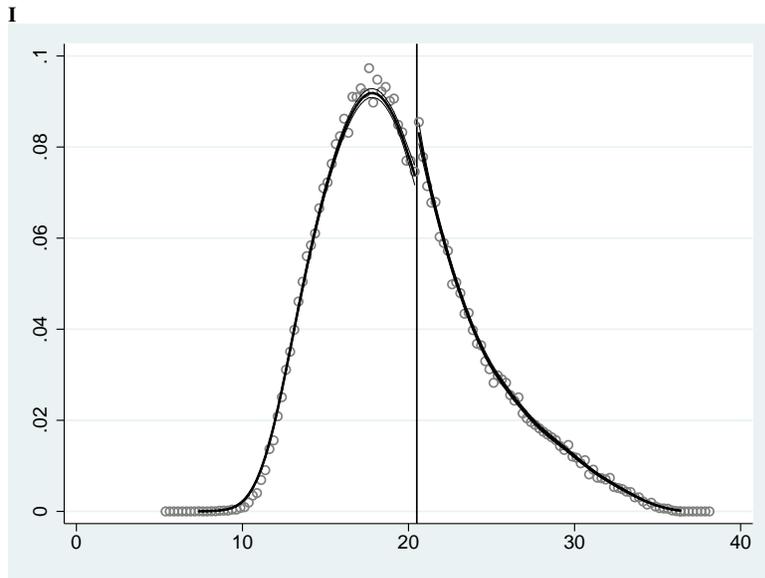
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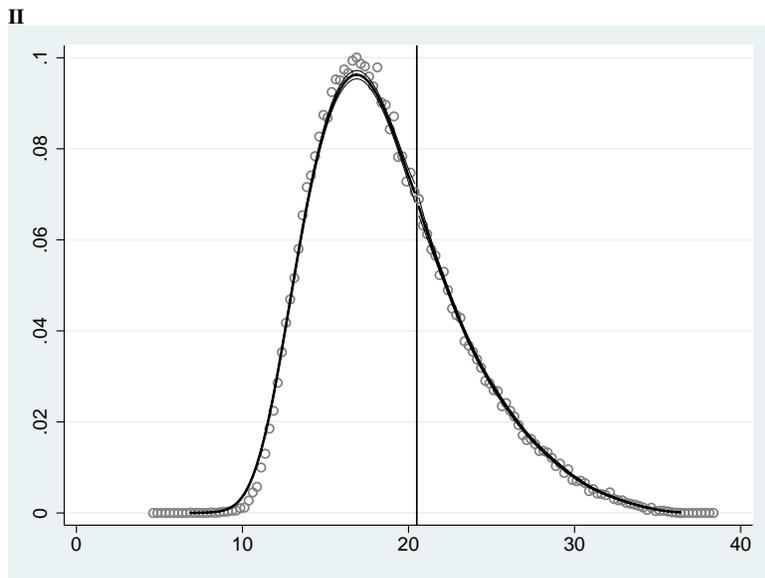
TABLE I: TELS Expenditure by Academic Year

Year	Expenditures
2004-2005	\$93,402,500
2005-2006	136,836,500
2006-2007	225,748,285
2007-2008	259,852,858
2008-2009	283,951,400

SOURCE - [Bruce & Fox \(2010\)](#)

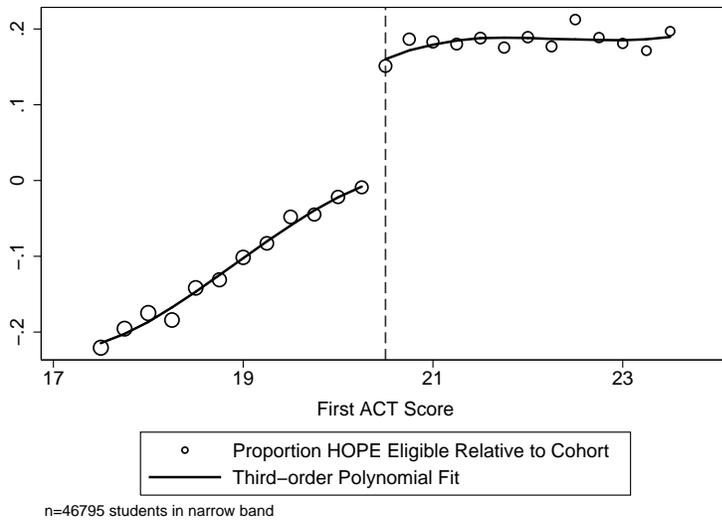


Discontinuity estimate (standard error):
0.166 (0.024)



Discontinuity estimate (standard error):
-0.006 (0.024)

FIGURE I: Local Linear Density Estimates of Best (I) and First (II) ACT Scores, 2006-2009
Tennessee High School Graduates ($n = 157,542$)



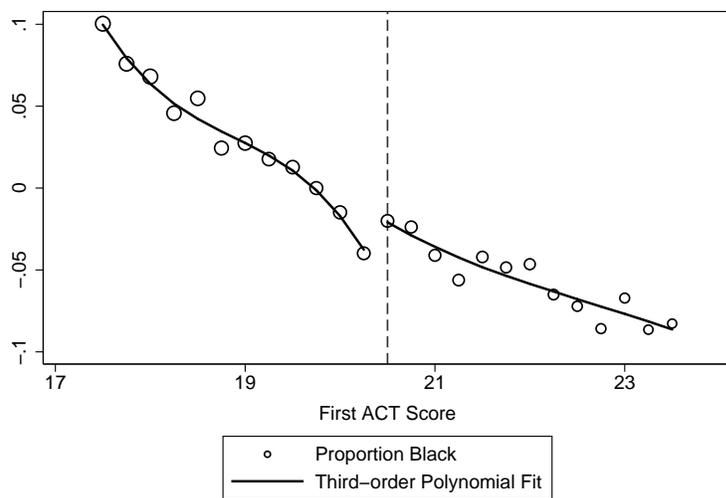
Discontinuity estimate (standard error):
 0.158 (0.018)

FIGURE II: HOPE Eligibility Relative to Cohort by First ACT Score, College-Going 2006-2009
 Tennessee High School Graduates

TABLE II: Matriculation Outcomes and Descriptive Statistics

	2006-2009 High School Graduates		2006-2009 College-Going High School Graduates	
	Mean	Discontinuity	Mean	Discontinuity
Enrolled in Any College (%)	75.7			
For-Profit College (%)	1.3		1.7	
Out-of-State College (%)	10.7		14.1	
In-State, Private College (%)	5.0		6.6	
In-State, Public Two-Year College (%)	26.7		35.2	
In-State, Public Four-Year College (%)	32.1		42.4	
First ACT Score	20.0 (1.7)		20.1 (1.7)	
Best ACT Score	20.7 (2.2)		21.0 (2.2)	
Male (%)	47.4	-1.0 [1.3]	47.1	0.5 [1.1]
Black (%)	16.1	4.3** [0.5]	17.2	3.9** [0.6]
Hispanic (%)	2.0	0.1 [0.4]	1.7	3.8E-02 [0.4]
Other, Non-Hispanic (%)	1.8	0.5 [0.4]	1.8	0.6 [0.5]
<i>n</i> (students)	46,795		35,440	

NOTES: Standard deviations in ACT scores are in parentheses below each mean. The sample is limited to students within 3 points of the 20.5-point HOPE threshold, excluding HOPE recipients with at least a 3.0 high school GPA. Discontinuities in covariates are measured at 20.5 ACT points, with third-order polynomial functions fitted to the relationship between each covariate and first ACT scores on either side of the threshold. Robust standard errors, clustered by first ACT score, are in brackets. ** indicates 1% statistical significance, * indicates 5% statistical significance, and † indicates 10% statistical significance.



Discontinuity estimate (standard error):
0.043 (0.005)

FIGURE III: Proportion Black Relative to Cohort by First ACT Score, College-Going 2006-2009
Tennessee High School Graduates

TABLE III: The Effect of Passing the HOPE Eligibility Threshold on the Likelihood of Going to Any College, by Gender

Dependent Variable	All Students		Females		Males	
Enrolled in Any College	0.025** (0.010)	0.022* (0.010)	0.004 (0.012)	-2.2E-04 (0.012)	0.048** (0.016)	0.046** (0.015)
n (students)	46,795	46,795	24,619	24,619	22,176	22,176
Controls for Gender, Race/Ethnicity?	No	Yes	No	Yes	No	Yes

NOTES: The table lists the reduced-form effect of passing the 20.5-point ACT threshold on the likelihood of enrolling in any college (Equation

1). All models control for cohort indicators and limit the estimating sample to students within 3 points of the threshold. Robust standard errors, clustered by first ACT score, are in parentheses. ** indicates 1% statistical significance, * indicates 5% statistical significance, and † indicates 10% statistical significance.

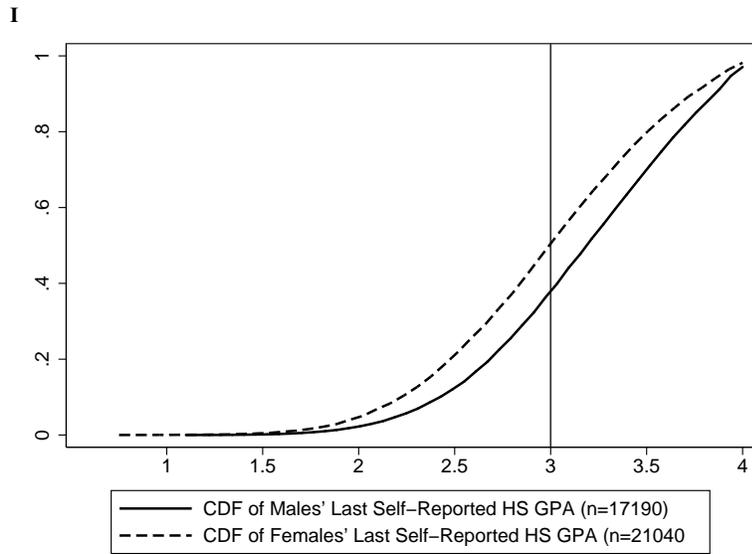
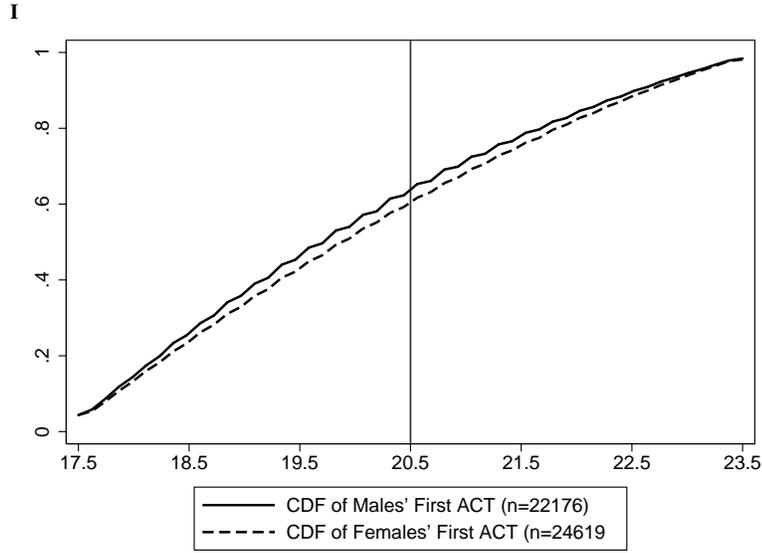


FIGURE IV: CDF of First ACT (I) and Last Self-Reported High School GPA (II), by Gender

TABLE IV: The Effect of HOPE Eligibility Matriculation Outcomes, by Gender

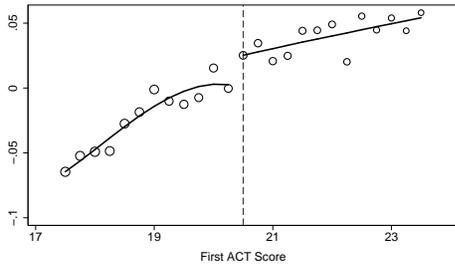
	All Students		Females		Males	
First Stage Estimates of the Effect of Passing 20.5 ACT Points on HOPE Eligibility						
HOPE Eligible	0.164** (0.014)	0.164** (0.014)	0.108** (0.012)	0.108** (0.012)	0.229** (0.023)	0.230** (0.024)
IV Estimates of the Effect of HOPE on Matriculation Outcomes						
For-Profit College	3.1E-04 (0.021)	0.001 (0.021)	0.015 (0.047)	0.016 (0.047)	-0.008 (0.021)	-0.007 (0.021)
Out-of-State College	0.010 (0.027)	-0.011 (0.026)	0.041 (0.085)	0.014 (0.087)	-0.009 (0.045)	-0.028 (0.047)
In-State, Private College	0.021 (0.052)	0.019 (0.052)	-0.038 (0.125)	-0.040 (0.126)	0.056 (0.039)	0.053 (0.038)
In-State, Public, Two-Year College	-0.253** (0.054)	-0.184** (0.046)	-0.240** (0.078)	-0.156* (0.073)	-0.258** (0.058)	-0.198** (0.052)
In-State, Public, Four-Year College	0.221* (0.090)	0.175* (0.085)	0.222 (0.138)	0.166 (0.135)	0.219* (0.093)	0.181* (0.086)
<i>n</i> (students)	35,441	35,441	18,757	18,757	16,684	16,684
Controls for Gender, Race/Ethnicity?	No	Yes	No	Yes	No	Yes

NOTES: The table lists the the effect of passing the 20.5-point ACT threshold on HOPE eligibility (Equation 2) and the local average treatment effect of HOPE eligibility on student matriculation outcomes (Equation 3). All models control for cohort indicators and limit the estimating sample to students within 3 points of the threshold. Robust standard errors, clustered by first ACT score, are in parentheses. ** indicates 1% statistical significance, * indicates 5% statistical significance, and † indicates 10% statistical significance.

TABLE V: Matriculation Discontinuities at the 20.5 ACT Threshold Among Students With and Without HOPE-Eligible GPA, by Gender

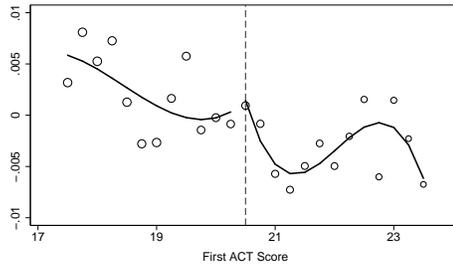
	All Students		Females		Males	
Private, In-State College	0.003 (0.009)	0.008 (0.013)	-0.004 (0.014)	-0.003 (0.011)	0.013 (0.010)	0.028 (0.027)
Public, In-State, Two-Year College	-0.041** (0.009)	-0.021† (0.012)	-0.026** (0.009)	-0.031 (0.019)	-0.059** (0.013)	-0.002 (0.020)
Public, In-State, Four-Year College	0.036* (0.015)	0.013 (0.018)	0.024 (0.016)	0.028 (0.019)	0.050** (0.019)	-0.018 (0.039)
<i>n</i> (students)	35,440	25,130	18,757	15,804	16,684	9,326
HOPE-Eligible with GPA?	No	Yes	No	Yes	No	Yes
Controls for Gender, Race/Ethnicity?	No	No	No	No	No	No

NOTES: The table lists reduced-form discontinuities in three matriculation outcomes at the 20.5-point ACT threshold (Equation 1). All models control for cohort indicators and limit the estimating sample to students within 3 points of the threshold. Robust standard errors, clustered by first ACT score, are in parentheses. ** indicates 1% statistical significance, * indicates 5% statistical significance, and † indicates 10% statistical significance.



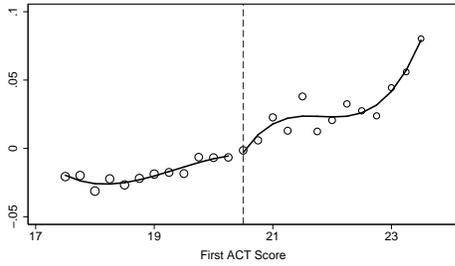
n=46795 students in narrow band

Any College
Discontinuity (st. err.)
0.025 (0.010)



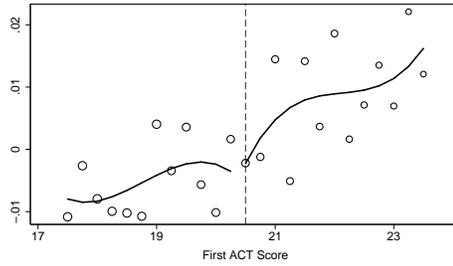
n=35440 students in narrow band

For-Profit College
Discontinuity (st. err.)
5.1E-05 (0.004)



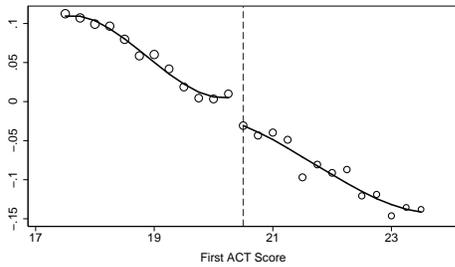
n=35440 students in narrow band

Out-of-State College
Discontinuity (st. err.)
0.002 (0.004)



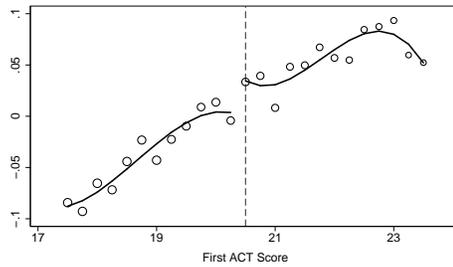
n=35440 students in narrow band

Private, In-State College
Discontinuity (st. err.)
0.003 (0.009)



n=35440 students in narrow band

Public, In-State, Two-Year College
Discontinuity (st. err.)
-0.041 (0.009)



n=35440 students in narrow band

Public, In-State, Four-Year College
Discontinuity (st. err.)
0.036 (0.015)

FIGURE V: Matriculation Outcomes of Tennessee's 2006-2009 High School Graduates, by First ACT

TABLE VI: Postsecondary Outcomes and Descriptive Statistics

2005-2008 Entering Freshman in Public Four-Year Colleges		
	Mean	Discontinuity
Enrolled Only One Semester (%)	9.3 (29.0)	
Total Semesters	4.6 (2.5)	
Total Credits	54.2 (37.7)	
Full-Time First Two Semesters ¹ (%)	88.0 (32.5)	
Full-Time First Four Semesters ¹ (%)	78.3 (41.2)	
Full-Time First Six Semesters ¹ (%)	80.2 (39.9)	
Last Observed GPA	2.06 (1.14)	
Bachelor's Degree Within Four Years ² (%)	7.1 (25.6)	
Any Earnings While Enrolled (%)	82.2 (38.3)	
Average Quarterly Earnings While Enrolled	955.7 (1115.8)	
First ACT Score	20.2 (1.7)	
Maximum ACT Score	21.0 (2.0)	
Male (%)	52.3 (49.9)	2.5 [2.3]
Black (%)	20.8 (40.6)	1.8 [2.5]
Hispanic (%)	2.2 (14.7)	1.1 [0.7]
Other, Non-Hispanic (%)	4.9 (21.6)	-2.4** [0.9]
Spring Entrant (%)	10.2 (30.3)	-0.7 [1.2]
Distance from Home (miles)	77.6 (109.1)	2.9 [5.4]
Missing Distance from Home (%)	0.1 (3.7)	0.3 [0.2]
<i>n</i> (students)	12,362	

NOTES: Standard deviations are in parentheses below each mean. The sample is limited to students within 3 points of the 20.5-point HOPE threshold, excluding HOPE recipients with at least a 3.0 high school GPA. ¹ Summary statistics for full-time enrollment over x semesters are limited to students who stayed in college at least that long. ² Summary statistics for Bachelor's degree receipt are limited to the 2005 cohort. Discontinuities in covariates are measured at 20.5 ACT points, with third-order polynomial functions fitted to the relationship between each covariate and first ACT scores on either side of the 20.5-point threshold. Robust standard errors, clustered by first ACT score, are in brackets. ** indicates 1% statistical significance, * indicates 5% statistical significance, and † indicates 10% statistical significance.

TABLE VII: The Effect of Tennessee HOPE Receipt on Post-Secondary Outcomes at the 20.5 Threshold, by Gender

	All Students		Females		Males	
First Stage Estimates of the Effect of Passing 20.5 ACT Points on HOPE Eligibility						
HOPE Eligible	0.267** (0.021)	0.262** (0.018)	0.293** (0.049)	0.306** (0.042)	0.234** (0.021)	0.214** (0.019)
IV Estimates of the Effect of HOPE on Post-Secondary Outcomes						
Enrolled Only One Semester	0.026 (0.029)	0.030 (0.029)	0.052 (0.049)	0.040 (0.047)	-0.012 (0.075)	0.033 (0.081)
Total Semesters	-0.144 (0.275)	-0.215 (0.307)	-0.249 (0.659)	-0.074 (0.735)	-0.052 (0.569)	-0.535 (0.641)
Total Credits	-6.4 (5.5)	-7.1 (6.0)	-8.7 (11.2)	-5.9 (12.7)	-4.7 (6.1)	-10.4 (7.2)
Full-Time First Two Semesters ¹	-0.006 (0.057)	-0.006 (0.056)	0.107 (0.083)	0.121 (0.080)	-0.124 (0.118)	-0.156 (0.133)
Full-Time First Four Semesters ¹	0.089 (0.103)	0.090 (0.102)	-0.087 (0.140)	-0.045 (0.151)	0.317* (0.152)	0.323* (0.164)
Full-Time First Six Semesters ¹	0.065 (0.126)	0.058 (0.133)	0.291* (0.142)	0.303* (0.144)	-0.324 (0.394)	-0.359 (0.401)
Last Observed GPA	0.103 (0.098)	0.110 (0.094)	0.271 (0.232)	0.258 (0.254)	-0.092 (0.204)	-0.184 (0.232)
Bachelor's Degree Within 4 Years ²	-0.082 (0.089)	-0.092 (0.093)	-0.103 (0.208)	-0.106 (0.214)	-0.082† (0.048)	-0.099† (0.057)
Any Earnings While Enrolled	-0.145* (0.066)	-0.148* (0.064)	-0.258* (0.130)	-0.245* (0.117)	-0.005 (0.104)	-0.018 (0.108)
Ave. Quarterly Earnings While Enrolled	-831.8** (204.4)	-823.7** (212.5)	-913.6* (465.0)	-953.4* (458.5)	-700.1* (278.1)	-568.0* (288.0)
<i>n</i> (students)	12,362	12,362	5,892	5,892	6,470	6,470
Controls for Gender, Race/Ethnicity, distance, spring entry?	No	Yes	No	Yes	No	Yes

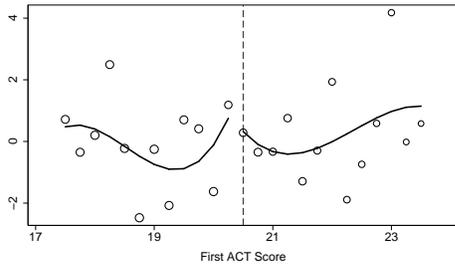
NOTES: The table lists the the effect of passing the 20.5-point ACT threshold on HOPE receipt (Equation 2) and the local average treatment effect

of HOPE receipt on postsecondary outcomes (Equation 3). All models control for cohort indicators and limit the estimating sample to students

within 3 points of the threshold. ¹ Estimates for full-time enrollment over *x* semesters are limited to students who stayed in college at least that

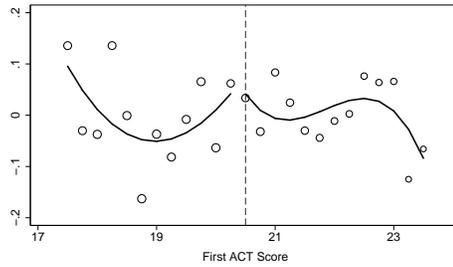
long. ² Estimates for Bachelor's degree receipt are limited to the 2005 entering cohort. Robust standard errors, clustered by first ACT score, are in

parentheses. ** indicates 1% statistical significance, * indicates 5% statistical significance, and † indicates 10% statistical significance.



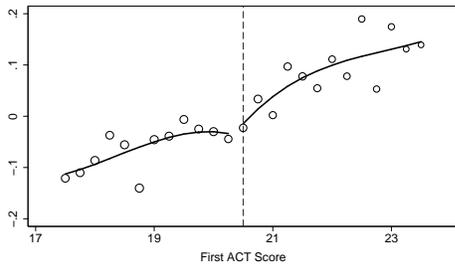
n=12324 students in narrow band

Credits Accumulated
Discontinuity (st. err.)
-1.702 (1.499)



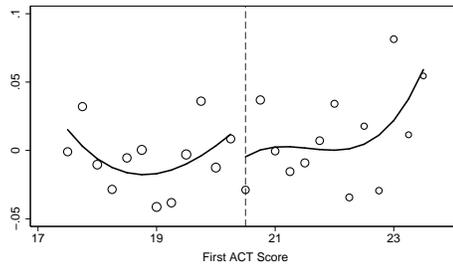
n=12362 students in narrow band

Semesters Enrolled
Discontinuity (st. err.)
-0.038 (0.076)



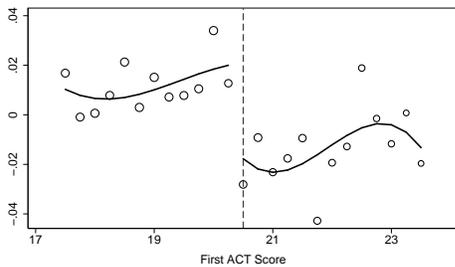
n=11596 students in narrow band

Last Observed GPA
Discontinuity (st. err.)
0.027 (0.027)



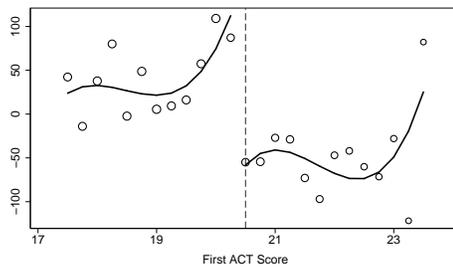
n=2680 students in narrow band

Bachelor's Degree Within Four Years
Discontinuity (st. err.)
-0.026 (0.030)



n=12362 students in narrow band

Any Earnings While Enrolled
Discontinuity (st. err.)
-0.039 (0.017)



n=12362 students in narrow band

Average Quarterly Earnings While Enrolled
Discontinuity (st. err.)
-221.7 (43.7)

FIGURE VI: Post-Secondary Outcomes of Tennessee Four-Year College Students Entering in 2005-2008, by First ACT

TABLE VIII: Postsecondary Outcome Discontinuities at the 20.5 ACT Threshold Among Students With and Without HOPE-Eligible High School GPA

HOPE-Eligible with GPA?	No	Yes
Enrolled Only One Semester	0.007 (0.008)	-0.002 (0.005)
Total Semesters	-0.038 (0.076)	-0.065 (0.064)
Total Credits	-1.7 (1.5)	-3.4** (1.1)
Full-Time First Two Semesters ¹	-0.002 (0.016)	-0.010 (0.008)
Full-Time First Four Semesters ¹	0.024 (0.030)	-0.026* (0.013)
Full-Time First Six Semesters ¹	0.017 (0.036)	-0.024 (0.015)
Last Observed GPA	0.027 (0.027)	-0.036 (0.047)
Bachelor's Degree ² Within Four Years	-0.026 (0.030)	0.011 (0.022)
Any Earnings While Enrolled	-0.039* (0.017)	0.007 (0.020)
Ave. Quarterly Earning While Enrolled	-221.7** (43.7)	-65.2* (26.7)
<i>n</i> (students)	12,362	18,588
Controls for Gender, Race/Ethnicity, distance, spring entry?	No	No

NOTES: The table lists estimated discontinuities in postsecondary outcomes at the 20.5-point ACT threshold (Equation 1), by relevance of the ACT threshold for HOPE eligibility. All models control for cohort indicators and limit the estimating sample to students within 3 points of the threshold.

¹ Estimates for full-time enrollment over x semesters are limited to students who stayed in college at least that long. ² Estimates for Bachelor's degree receipt are limited to the 2005 cohort. Robust standard errors, clustered by first ACT score, are in parentheses. ** indicates 1% statistical significance, * indicates 5% statistical significance, and † indicates 10% statistical significance.

TABLE IX: The Effect of HOPE Eligibility on Postsecondary Outcomes: Cohort Analysis

Outcome	Means	Results				
		All	Females	Males	$17.5 \leq ACT_i \leq 23.5$	Bottom 80% College GPA
Enrolled Only One Semester	0.045 (0.207)	-0.027** (0.002)	-0.025** (0.003)	-0.031** (0.004)	-0.018** (0.003)	-0.012** (0.003)
Total Semesters	5.999 (2.914)	0.367** (0.053)	0.503** (0.068)	0.221** (0.085)	0.274** (0.068)	0.212** (0.054)
Total Credits	79.4 (43.5)	6.0** (0.8)	8.2** (1.0)	3.0* (1.3)	3.6** (1.0)	-0.9 (0.8)
Full-Time First Two Semesters ¹	0.953 (0.211)	0.027** (0.003)	0.028** (0.003)	0.027** (0.004)	0.013** (0.003)	0.014** (0.002)
Full-Time First Four Semesters ¹	0.913 (0.281)	0.057** (0.004)	0.065** (0.005)	0.049** (0.007)	0.025** (0.005)	0.037** (0.004)
Full-Time First Six Semesters ¹	0.907 (0.291)	0.052** (0.006)	0.057** (0.007)	0.044** (0.010)	0.023** (0.007)	0.028** (0.006)
Last Observed GPA	2.697 (2.257)	0.076 (0.064)	0.031 (0.084)	0.143 (0.098)	-0.027 (0.090)	
Bachelor's Degree ² Within Four Years	0.194 (0.396)	0.002 (0.009)	0.000 (0.012)	-0.001 (0.012)	-0.008 (0.011)	-0.074** (0.009)
Any Earnings While Enrolled	0.822 (0.383)	-0.002 (0.006)	-0.007 (0.007)	0.011 (0.009)	0.002 (0.007)	0.005 (0.006)
Ave. Quarterly Earnings While Enrolled	939.4 (1095.6)	-12.8 (26.5)	18.9 (34.0)	-51.0 (42.3)	-19.3 (35.3)	45.2 [†] (27.5)
<i>n</i> (students)	81,521	81,521	44,591	36,930	44,675	66,013

NOTES: The leftmost column lists means and standard deviations for the 2002 and 2005-2008 cohorts. Other columns list selected coefficients from

Equation 4, estimating the difference-in-difference impact of HOPE eligibility on postsecondary outcomes. ¹ Estimates for full-time enrollment over x semesters are limited to students who stayed in college at least that long. ² Estimates for Bachelor's degree receipt are limited to the 2002 and 2005 cohorts. Unreported control variables include an indicator for post-2003 cohorts, an indicator for $ACT \geq 20.5$, linear and quadratic trends, gender, race/ethnicity, distance from home, and indicators for spring entry and missing distance. Robust standard errors are in parentheses. ** indicates 1% statistical significance, * indicates 5% statistical significance, and [†] indicates 10% statistical significance.

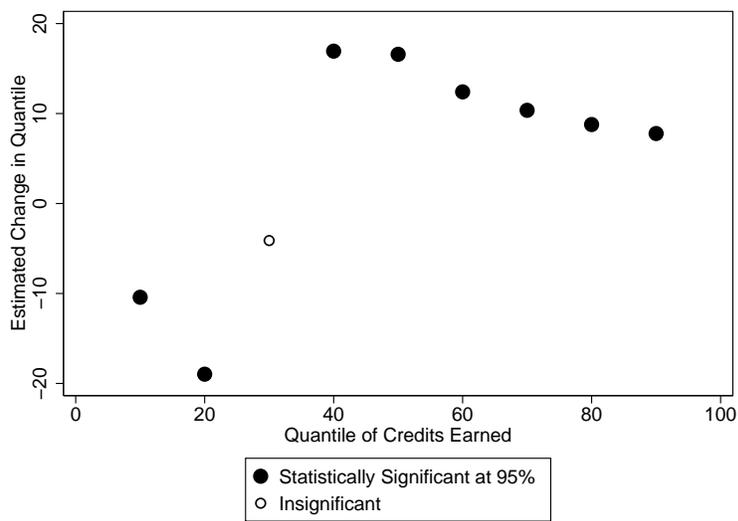


FIGURE VII: The Impact of HOPE Eligibility on Quantiles of Credits Earned

NOTES: The figure plots coefficients from quantile regressions analogous to Equation 4. For each quantile q , coefficients are estimates of the impact of HOPE eligibility on the value of the q^{th} quantile of cumulative credits.