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# ABSTRACT

# The Effects of Financial Aid Loss on Persistence and Graduation: A Multi-Dimensional Regression Discontinuity Approach*

For years Georgia's HOPE Scholarship program provided full tuition scholarships to high achieving students. State budgetary shortfalls reduced its generosity in 2011. Under the new rules, only students meeting more rigorous merit-based criteria would retain the original scholarship covering full tuition, now called Zell Miller, with other students seeing aid reductions of approximately 15 percent. We exploit the fact that two of the criteria were high school GPA and SAT/ACT score, which students could not manipulate when the change took place. We compare already-enrolled students just above and below these cutoffs, making use of advances in multi-dimensional regression discontinuity, to estimate effects of partial aid loss. We show that, after the changes, aid flowed disproportionately to wealthier students, and find no evidence that the financial aid reduction affected persistence or graduation for these students. The results suggest that high-achieving students, particularly those already in college, may be less price sensitive than their peers.

**JEL Classification:** I22, I23, H75
**Keywords:** student aid, multi-dimensional regression discontinuity, HOPE

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## 1. Introduction

Where and how financial aid is best targeted is a perennial policy question. Much of the existing research focuses on the provision of need-based grants, such as federal Pell, on promise scholarships, or on access to non-grant aid such as loans. Relatively less work is devoted to merit-based aid programs, which target aid to what is often a very different set of students. Moreover, research is largely focused on aid provision, rather than loss, which is increasingly common and can have very different impacts. In this study we ask what happens when students lose merit-based aid by analyzing an unanticipated change to Georgia's HOPE scholarship program, effectively making it less generous across an arbitrary threshold. The circumstances surrounding this policy change provide a unique natural experiment to examine how students respond to an exogenous loss of substantial, but not total, financial aid mid-college. At the margin, we observe students lose roughly 15% of aid they should reasonably have expected to receive for the remainder of college.

Understanding the effects of aid loss has important policy implications for several reasons. First, millions of students rely on financial aid each year, and loss of aid could potentially affect enrollment, work, and graduation decisions. Students in federal or state need-based programs may lose funding because of failure to renew and verify eligibility (Evans, et al. 2017), or because of budget cuts that threaten funding for programs. Similarly, students in merit-based programs must continue to meet eligibility criteria, such as grade point average while in college, or risk losing some or all of their scholarship. Second, it is not evident that students will respond to the loss of financial assistance in the same way they respond to the awarding of financial aid. Loss aversion suggests that people tend to overvalue losses relative to gains (Kahneman et al., 1990). Therefore, it is possible that the negative effects of losing existing financial aid would be larger than the positive effects of gaining an equal amount of additional aid. Third, knowing how financial aid affects students already in college has potentially important implications for focusing financial aid policy and efforts to promote college persistence and graduation. Current policies largely provide the same funding level in each year. If effects are different at the intensive compared with extensive margins, policymakers and schools may be able to target resources more efficiently and effectively.

Studying merit-based programs is important as well. Resource-limited states and universities must decide whom to target aid toward, with a tradeoff between merit- and need-based populations. From the perspective of a central planner, equity and access are key concerns, as is how effective the aid will be in enrolling and retaining students. On the one hand, need-based aid may bring the marginal student into college, but have small effects on overall graduation rates. On the other, merit aid may help attract high achieving students, but might also result in regressive wealth transfers if high achieving students are also wealthy.

We examine this issue by exploiting an unanticipated change in Georgia's HOPE Scholarship program, announced near the end of the 2010-11 academic year. For many years, Georgia's HOPE scholarship provided full tuition, partial fees, and a book allowance for Georgia students attending Georgia's colleges and universities if they earned a 3.0 high school grade point average (GPA) and maintained it while in college. Projected budget shortfalls led the state to reduce the generosity of the grant, effectively creating a two-tiered system beginning with the fall semester of the 2011-12 school year. Under the new guidelines, only students who graduated high school with a 3.7 GPA, had an SAT (or ACT) score of 1200 (26), and maintained a 3.3 GPA in college would retain full tuition funding under what would now be called the Zell Miller Scholarship; in other words, for students meeting these requirements, little changed, although books and fees were no longer covered. Those not meeting those criteria, but who were eligible for the original HOPE scholarship, would face a reduced scholarship that would not fully cover tuition or provide for fees or books. Compared to the prior spring semester, both groups lost at least some money, but the group not eligible for the Zell Miller Scholarship lost more, with full time students at the state's research institutions facing a gap of almost $1,000 per year between tuition charges and the HOPE Scholarship award.[1] Given that only 13 percent of HOPE-eligible students in our sample qualified for full tuition Zell Miller Scholarships, the vast majority of these students unexpectedly lost at least some merit-based financial aid.[2] As such, this change provides a unique natural experiment allowing us to ask, *what happens when students lose aid in the middle of college*?

Using student-by-semester data from the Georgia Board of Regents for students entering the University System of Georgia (USG) for the first time in 2009-10 and 2010-11, who were ostensibly entering their sophomore and junior years when the change took effect, we follow students through five years spanning the two scholarship regimes and employ a regression-discontinuity design to compare outcomes for students just above and just below the new eligibility cutoffs. Two salient features distinguish this case from prior work, in particular Carruthers and Ozek (2016) who study aid loss in Tennessee. First, the policy change relies in part on eligibility cutoffs determined *before* students entered college, meaning students could not strategically respond to the policy to affect eligibility on those margins. Second, the loss was focused among very high achieving students well into their college careers, allowing us to identify whether reduced funding affects student retention and graduation at this margin.

We find that failing to meet eligibility criteria across the cutoff led to an approximate 75 percentage point decrease in the likelihood of receiving the full scholarship, yielding roughly a 15 percent

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[1] The exact number is $918 and is based on the table cited in Footnote 7, not on our data. This assumes that the student took 15 credits per semester

[2] See Table 1. Note that some of this 87% did not enroll in the following semester.

loss in funding at the cutoff. While the drop in funding is modest, and acknowledging that our power is limited, we find no evidence of an effect on enrollment in the following academic year; our point estimates allow us to rule out effects larger than a one percentage point change. Further, we do not find evidence that it changed the likelihood of graduation. We also find that those losing the scholarship do not take out more in loans, suggesting that these students may not have been facing binding capital constraints. While the amount of funding loss that we study is smaller than the complete loss of funding (approximately $4,000 per year at four-year institutions and $2,000 per year at two-year institutions) in Carruthers and Ozek (2016), it is similar in magnitude to the average changes in financial aid studied in several other papers, such as Marx and Turner (2019), Barr, Bird, and Castleman (2017), and Denning and Jones (2019), the first two of which find educational effects.

While these results run counter to some of the existing literature (e.g. Bettinger, 2004, 2015; Dynarski, 2008; Scott-Clayton, 2011; Castleman and Long, 2013; Clotfelter et al., 2018), they are not necessarily surprising. Where prior work largely focuses on need-based aid, money seems to matter. But as we demonstrate, the merit-based nature of the aid program distributed funding disproportionately to students from wealthier families. In particular, the Zell Miller program targeted very high achieving students who had already persisted through their first or second year of college. The average Zell recipient had a family adjusted gross income (AGI) of $125,000, roughly double the state and national average.[3] We also do not find effects on less wealthy, though high-achieving, students, as they were eligible for other aid programs, such as Pell Grants. Hence, while the students themselves were made unambiguously worse off through the funding loss, it does not appear that they were bound tightly by financial constraints such that they would drop out from a moderate negative aid shock. These results, taken together with prior work, suggest that the effect of aid on completion is not the same for students at all margins of ability and wealth.

## 2. Background

### 2.1 Prior work

Undergraduate students in the United States have traditionally financed their college educations through a mix of grants, loans, earnings and family contributions, with the relative contribution of each determined primarily through information provided on the Free Application for Federal Students Aid (FAFSA). The process has been widely criticized for being complicated, lacking transparency, and for not providing timely information to students and their families (Dynarski and Scott-Clayton, 2013). Responding at least in part to these concerns, many states and localities have adopted broad merit-based and place-based

[3] Federal Reserve Bank of St. Louis.

scholarship programs that provide guaranteed tuition to students who meet clearly-defined performance or residency criteria.

Georgia's HOPE Scholarship program, started in 1993, was among the first broad-based merit scholarship programs and has been a focus of much of the research examining the effects of merit aid. Not surprisingly, college access has been a primary focus of this work, starting with Dynarski (2000) who used CPS and IPEDS data to compare college attendance rates in Georgia and other southeastern states before and after the start of the HOPE Scholarship program. She found that HOPE induced a 7-8 percentage point increase in college attendance, with the effects concentrated among white students. Similarly, Cornwell, Mustard and Sridhar (2006) found that HOPE induced an increase in college-going in Georgia of approximately 6 percentage points, but found larger effects among African-American students. Both studies found that increases were concentrated at four-year public institutions. Bruce and Carruthers (2015) examined Tennessee's similar and newer HOPE Scholarship program and found no significant effect on enrollment, but that students shifted from two-year to four-year institutions.

While a relatively large body of literature has examined the effects of financial aid increases on college enrollment and persistence outside of Georgia,[4] less research has examined financial aid *loss*. Bettinger (2004) suggests that changes in financial aid may be more relevant than levels of aid to students' decisions about continuing in school. The issue is particularly salient in studying merit aid programs because of the large number of students who lose the scholarships during college. Most merit aid programs require not only initial qualification based on high school GPA, often in combination with SAT or ACT eligibility cutoffs, but also require students to meet performance benchmarks in college to retain the scholarships. Henry, Rubenstein and Bugler (2004) compare persistence and graduation for a sample of borderline Georgia HOPE recipients and non-recipients and find significantly higher persistence and graduation only for HOPE recipients who retained their scholarships. They report, though, that 85% of their sample of borderline recipients lost the scholarship at the first benchmark and only 3.5% kept it for four years.

Concerning aid loss, our work builds most directly on Carruthers and Ozek (2016), who use a regression discontinuity design to examine the effects of scholarship loss on students in Tennessee's HOPE Scholarship. Observing students across the 3.0 college GPA cutoff, the authors find only modest changes to enrollment behavior and no long-term effects on graduation. They do find that students losing scholarships recoup about 14 percent back through increased labor force participation.

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[4] See, for example see Bifulco, et al. (2019); Angrist et al. (2016); van der Klaauw (2002); Dynarski (2002); Castleman and Long (2013); Bettinger (2004, 2015); Barr (2016, Forthcoming); Clotfelter et al. (2018); and Erwin and Binder (2017). See also Sjoquist and Winters (2012, 2015).

## 2.2 HOPE and Zell Miller in Georgia

Following the Great Recession, Georgia faced stagnant lottery revenue, increasing numbers of HOPE-eligible students, and rising tuition costs, leading to projected deficits in HOPE Scholarship funding. To address these potential shortfalls, Georgia lawmakers in 2011 dramatically increased eligibility requirements for full scholarships and reduced HOPE Scholarship benefits. A new program, the Zell Miller Scholarship, was introduced offering full tuition for students with a minimum 3.7 high school GPA and combined 1200 SAT score (or 26 on the ACT).[5] A minimum 3.3 college GPA is required to keep the scholarship. The previous HOPE Scholarship program was retained for students achieving a 3.0 GPA, but benefits were reduced to a portion of the previous year's tuition. For both groups, coverage for fees and a book allowance were eliminated. A full-time HOPE Scholarship recipient attending one of the state's research universities, for example the University of Georgia or Georgia Tech, and taking 15 credit hours would be eligible to receive $3,182 each semester. A Zell recipient at the same university taking the same number of courses would be eligible for $3,641 per semester, or 14 percent more. For a comprehensive university such as Kennesaw State University, these numbers are $2,068 and $2,367 also 14 percent more.[6]

Key to our identification strategy is the fact that students already enrolled in college and receiving HOPE Scholarships when the changes were announced were not grandfathered in. Thus, some students lost aid despite meeting previous HOPE requirements. More specifically, students already in the state university system were required to meet both the high school eligibility requirements for a Zell Miller Scholarship (3.7 high school GPA and 1200 SAT or 26 ACT score) and the college maintenance requirement (3.3 college GPA). HOPE Scholarship renewal requirements remained at a 3.0 college GPA as before. Students with a 3.0 or better cumulative college GPA who would have been eligible for full tuition, partial fees and a book allowance under the previous eligibility requirements now received only the partial tuition scholarship beginning in 2011-12, unless they achieved the three cutoffs required for Zell Miller; if they met these cutoffs, they would receive full tuition (but no books and fees).

The renewal requirements for both scholarships are the same with the exception of college GPA, which is 3.0 for HOPE and 3.3 for Zell. It is possible that this higher requirement could also affect student decision-making on margins such as course-taking, number of credits, major choice,[7] and time to

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[5] These requirements apply to students graduating from an eligible high school; one exception is that valedictorians and salutatorians (who we do not observe) qualify for Zell. Students that graduate from an ineligible high school or home study program face different requirements. Students also need to apply for Zell by either filling out a FAFSA or the Georgia Student Finance Application (GSFAPPS) by a deadline. The full legislation is found at http://www.legis.ga.gov/Legislation/20112012/112820.pdf.

[6] Scholarship awards vary by institution according to tuition rates, credit hours and year, as listed at: https://apps.gsfc.org/main/publishing/pdf/common/FY2012_HOPEandZellMillerCombined.pdf. The University of Georgia, Georgia Tech, and Georgia College and State University each used a flat tuition schedule for 1-6 and 7-15 credits, meaning that HOPE covered a much smaller percentage of tuition for 7 credits than 15 credits, while Zell covered full tuition regardless of credits. Other schools' tuition was based on credits, and HOPE covered a constant proportion of the tuition.

[7] In particular, it is possible that students may shift to an "easier" major in order to earn a higher GPA. This could lead to higher college graduation. A related paper, Sjoquist and Winters (2015) find evidence consistent with state-level, merit-based financial

graduation. Another difference between the HOPE and Zell Miller, as explained more fully in Footnote 6, is that for the three institutions that employed a fixed tuition schedule, HOPE covered a much larger percentage of tuition for 15 credits versus 7 credits, while Zell Miller covered the full tuition regardless of credits. It is possible that this would lead some students who receive Zell Miller to take fewer credits.

These changes were announced in the spring of the 2010-11 academic year and were effective in the fall semester of the following school year, giving students little time to increase their college GPAs in response to the change to attempt to qualify for Zell Miller. More important for our identification strategy, though, is that Zell Miller eligibility for students already in college was based, in part, on their high school performance, making it impossible for students to change their behavior in order to qualify. This allows us to compare similar groups of students: students receiving full tuition scholarships and those receiving partial tuition scholarships.

## 3. Data

Our data come from the Georgia Board of Regents and contain information on each student enrolled in the University System of Georgia (USG), Georgia's four-year college system (technical colleges are under a different system). We use data for the entering cohorts of 2009 and 2010, who were already enrolled in college when the policy change took place. These data include demographics, such as high school GPA[8] and SAT/ACT scores; USG institution attended; HOPE/Zell status;[9] graduation status (within the University System of Georgia); information on grants, scholarships and student loans;[10] and adjusted gross income (AGI)[11]. We use these data to construct both treatment and outcome measures. The vast majority of Zell Miller award amounts were not reported for Georgia State University students. We therefore exclude such observations from the equations and summary tables involving HOPE and Zell award amounts (for all regressions, this is the HOPE+Zell variable and the Total Grants variable.)[12]

After dropping the observations that are missing high school GPA, test score (missing both SAT

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aid programs decreasing the probability of earning a STEM degree.

[8] The high school GPA we use is not the usual high school GPA, but is calculated specifically for HOPE and Zell eligibility and includes only certain courses. Throughout, high school GPA refers to HOPE high school GPA.

[9] We classify someone as having receiving HOPE or Zell if they are coded as such in the HOPE data files we received from the data provider, who indicated that this is the best measure of HOPE/Zell status in the data; the HOPE and Zell dollar amount data are less reliable results should be interpreted accordingly. If a student is classified as having received both HOPE and Zell, we code them as receiving Zell. Some students are coded as having received HOPE or Zell, but the financial aid data indicates that they received $0 of HOPE or Zell aid, or they are not matched to a record in the financial aid data; in such cases, we still consider them as having received HOPE or Zell. We conduct a robustness check where we exclude such individuals.

[10] Financial aid data, including Pell, were matched according to school-term; if a student had a financial aid data observation at another institution in the semester not included in the main, student dataset, this is not used. When defining grants, we do not include HOPE or Zell scholarship money.

[11] We recode negative AGIs to be 0, and take the average AGI up to Spring 2010-11. Those who always have a missing AGI are not included in the AGI results.

[12] To quantify how many students we lose from the HOPE+Zell and Total Grants equations, we find that the sample defined by bandwidths (described below) of 0.1 for HS GPA and 0.5 for test score decreases by a relatively modest 5.7% when Georgia State University students are excluded.

and ACT), and Spring 2010-11 college GPA, our main sample restriction is to consider only those students who received HOPE in Spring 2010-11 as we want to compare students who lost partial funding due to factors beyond their control at that time. For the 2009 (2010) cohort, we restrict to those who graduated high school in 2008 or 2009 (2009 or 2010), who were born in 1989 (1990) or after, and whose earliest matriculation term is in the summer or fall of 2009-10 (2010-11).[13] This covers the vast majority of students. We also drop the small number of students who were enrolled at more than one institution in Spring 2010-11 or Fall 2011-12, and those who have a college graduation date before Fall of 2011-12.

Table 1 shows summary statistics, after applying these sample restrictions, for students enrolled as of Spring 2010-11 by enrollment cohort and HOPE receipt. Column 1 is limited to students who did not receive HOPE prior to the policy change, while column 2 is limited to those who did, some of whom were affected by the transition to Zell Miller. Column 3 combines the previous columns. HOPE students are more likely to be female and less likely to be black than the non-HOPE recipients. They are also less likely to have ever received Pell. Importantly, HOPE recipients come from wealthier families on average than non-HOPE earners, with AGIs that are about 40 percent higher.

As the scholarship is merit based, HOPE recipients have substantially higher high school GPAs, college GPAs and college entrance exam scores than non-recipients. At the bottom of Table 1 we show that 13 percent of HOPE recipients received Zell Miller Scholarships in the first full academic term the program was in effect.[14] These students saw no change in their financial aid due to the eligibility change. Said differently, 87 percent were reverted to the new HOPE scholarship, seeing their grant aid reduced.

We also note that only a small number of students with HOPE through spring of the 2010-11 academic year were not enrolled the following fall (7 percent). Thirty-two percent of HOPE students graduated within four years,[15] much higher than the state average. Finally, we show borrowing and grant aid in fall of the 2011-12 academic year.

Table 2 displays differences in financial aid received before and after the policy change (where the difference is constructed by subtracting the amount in the Spring 2010-11 semester from the amount in the Fall 2011-12 semester), split into several categories of funding, including Loans, Grants (non-HOPE/Zell), HOPE, and Zell. Recalling that the analysis sample includes only those who received HOPE in Spring 2010-11, we create three groups based on what type of HOPE or Zell funding the student received in the Fall 2011-12 semester. *HOPE Losers*, those who did not receive HOPE in the following

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[13] We also include students whose first-observed matriculation term was earlier than this, but whose first term after dual enrollment terms (based on their enrollment code) happened during these semesters.

[14] This does not include the summer semester of calendar year 2012 during which time Zell was technically in effect. We do this because not enrolling in summer would not imply that a student had dropped out.

[15] We define graduation within four years as graduating by the spring of the fourth year, where the fourth year is the same for all students within a cohort.

Fall, took out about $1,000 more in loans compared to the Spring.[16] Despite this, total resources dropped considerably due to the loss of HOPE. *HOPE Persisters,* those who carried HOPE through to the following Fall, borrowed about $345 more and received about $730 less in HOPE. In total, they received $480 less compared to the Spring. *Zell*, those who transitioned to Zell in the Fall, received about $500 less in Zell than they did with HOPE in the previous semester, most likely due to the loss of funding for books and fees. Thus, while there was a drop in aid even for Zell Miller recipients, it was smaller than that for non-Zell recipients. We note here that these calculations do not take into account factors such as institution and number of credits attempted, which can also change. It is important to recognize that our regression discontinuity strategy compares individuals close to cutoffs, making the samples much more comparable than the numbers presented in this table. In fact, we will show that across the cutoff, those not receiving Zell Miller Scholarships lose about 15% of their funding on average compared to Zell Miller recipients.

## 4. Empirical strategy

Because Zell eligibility is based on being above more than one cutoff, we use multi-dimensional RD methods. Our main approach, similar to that of Choi and Lee (2018), employs a two-dimensional RD, conditional on being above the third cutoff. It is quite flexible and yields local average effects over the entire estimation region.

We present results with the two cohorts pooled together to increase power.[17] In the appendix, we present figures that show a one-dimensional RD, conditional on being above the other two cutoffs, in the spirit of Jacob and Lefgren (2004) and Matsudaira (2008). Since this is simply a less generalizable version of the two approaches we use, we show these results to demonstrate that they do not add information or affect results.[18]

For several reasons our preferred specification uses the two cutoffs determined before entering college: HS GPA and SAT/ACT score. For completeness, we also present variations using all three cutoffs as robustness checks. We focus on HS GPA and test score and not college GPA for three reasons. First, our measure of college GPA is a noisy version of the GPA used to determine eligibility, and thus does not predict Zell status perfectly.[19] Second, the Zell scholarship requirements were announced during the

[16] A common reason for these students to lose HOPE is falling below a 3.0 College GPA at the most recent checkpoint for determining HOPE eligibility. Checkpoints occur at 30, 60, 90 attempted hours, as well as every Spring. Table 2 does not illustrate whether a student lost HOPE at a checkpoint, but rather whether they no longer had HOPE in the Fall semester following the most recent checkpoint. Another reason is not making sufficient academic progress, such as not progressing towards degree quickly enough.

[17] The appendix presents the main table of results separately for each cohort.

[18] One approach to the multi-dimensional RD case is to center all forcing variables and take the minimum, effectively reducing the estimating specification to a single-dimensional RD. This approach requires the forcing variables to be on a common scale, which we do not have: one is a test score the other two are GPAs. Moreover, each GPA is at a different point in the distribution which would force us to assume a small change in HS GPA near 3.7 is comparable to a similar change in college GPA near 3.3.

[19] The 3.3 college GPA is based on a "HOPE GPA." Our data contains a different measure of college GPA, which does not always

Spring 2011; college GPA is based on grades at the end of this semester and potentially during summer, therefore college GPA is arguably endogenous. Third, the Zell Miller scholarship is a merit-based program. The components determined during high school—high school GPA and test score—are the important margin; college GPA is a maintenance component and arguably a result of additional funding. Scott-Clayton and Schudde (2019) argue that performance standards can improve efficiency, but this can come at the cost of increasing inequality.

While our preferred specification does not use college GPA as a running variable, we condition the sample on being over the college GPA cutoff. We do this to tighten the contrast between treatment and control by excluding those at little or no risk of receiving a Zell Miller Scholarship. In fact, less than 4% of Zell Miller recipients in the sample had a college GPA below the cutoff, despite our noisy measure of this variable. As a robustness check, we also present main results without making this sample restriction.

Choosing bandwidths around the cutoff for multi-dimensional regression discontinuity is not a straightforward matter as it is in the single RD case. Hence, we use two different bandwidth selection methods to ensure results are not sensitive to these choices, and also employ several approaches in terms of flexibly modeling running variables in order to ensure that our results are robust to various decision rules.

### 4.1 A Two-Dimensional RD Framework

We first use a flexible model that estimates one local average treatment effect using both cutoffs, as in Choi and Lee (2018). The general form of our estimating equation is:

$$y_i = \alpha + \beta Above_i + \Delta * f(Test_i, HSGPA_i) + \Gamma \mathrm{X_i} + \epsilon_i \,. \tag{1}$$

The variable of interest, $Above$, is an indicator for being above both the test score and HS GPA cutoffs (or all three cutoffs in some specifications shown in some of the robustness checks); *X* is a vector of covariates, including year of high school graduation, gender, race/ethnicity, and indicator for whether the higher test score was the SAT (vs. ACT), Pell Grant receipt, credits received by the end of Spring 2010-11,[20] and attendance at one of the state's flagship schools (the University of Georgia or Georgia

match HOPE GPA. We focus on our measure of GPA at the end of the Spring term, the most common – and easiest to identify - eligibility checkpoint. The college GPA variable is much noisier (in terms of predicting Zell receipt at the cutoff) than the high school GPA and test score variables as shown in Appendix Figure A.1. For the 2009 cohort those just to the left of the college GPA cutoff are about as likely to receive Zell as those just to the right (conditional on being above the two other cutoffs).

[20] Credits are measured at the end of the Spring 2010-11 term, before the policy change went into effect, but after it was announced. Thus, if students change their credits in response, this variable is endogenous. This is similar if the policy affected Pell as this variable is 1 if the student received Pell money during any time in the sample. Results are presented without covariates in the Appendix.

Tech) in Spring 2010-11.[21] *f( )* is a function of the two running variables in our main specifications, test score and HS GPA, which we describe below. The sample is conditional on the centered college GPA variable being at or above 0.

Figure 1 depicts the treatment groups graphically, with SAT/ACT test score on the x-axis and HS GPA on the y-axis. Because both are centered at the respective cutoffs, observations in the upper right quadrant, represented by the area consisting of regions 5, 6, 9, and 11, are above both cutoffs (*Above* is equal to 1), and are thus predicted to be eligible for Zell among these two dimensions (conditional on also being above College GPA).

We estimate several different versions of Equation 1, each using a different variant of the function *f( ),* and each using local linear regression. In our preferred specification we allow each continuous running variable to vary on either side of the cutoffs and also include two interaction terms, indicating students above and below the cutoffs. In this case, *f( )* takes the form:

$$\Delta f(\,) = \delta_1 Test\ Below_i + \delta_2 Test\ Above_i + \delta_3 HSGPA\ Below_i + \delta_4 HSGPA\ Above_i + \delta_5 (Test\ Below_i * HSGPA\ Below_i) + \delta_6 (TestAbove_i * HSGPA\ Above_i), \quad (2)$$

where *Test Below* and *Test Above* are continuous forcing variables derived from the centered test score. *HSGPA Below* and *HSGPA Above* serve the same purpose for our centered *HS GPA* variable. *Test Below* is equal to test score if test score is less than 0; otherwise it is 0. *Test Above* is equal to test score if test score is greater than 0; it is 0 otherwise. *HSGPA Below* and *HSGPA Above* are analogously-defined. *Test Below * HSGPA Below* is an interaction of *Test Below* and *HSGPA Below*, while *Test Above * HSGPA Above* is an interaction of *Test Above* and *HSGPA Above*.[22]

### *4.1.1 Bandwidth Selection*

The traditional one-dimensional RD requires the researcher to select a single bandwidth that determines which observations will be used in estimation. Figure 1 illustrates how this extends to the two-dimensional case. We first use a one-dimensional bandwidth selection technique to set bandwidths separately for test score and HS GPA.[23] These are indicated in the figure by BW_TestScore and BW_HSGPA. The result is an L-Shaped region of observations for analysis which compares students on either side of each cutoff,

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[21] We control for cohort, but do not allow covariates to vary across cohort.

[22] In Appendix Tables A.3-A.9, we also present a version that includes Test Below interacted with HS GPA Above, and Test Above interacted with HS GPA Below. Results are nearly identical.

[23] We use the rdbwselect command (with the mserd bandwidth selection procedure—see Calonico, Cattaneo, and Titiunik, 2014) from the rdrobust package in Stata (Calonico, Cattaneo, Farrell and Titiunik, 2017). We do not include covariates in selecting bandwidths.

excluding those who are far away from both cutoffs.[24]

$$[Abs(Test) \leq BW_{Test} \ \& \ HSGPA \geq -BW_{HSGPA}]$$
$$or \tag{3}$$
$$[Abs(HSGPA) \leq BW_{HSGPA} \ \& \ Test \geq -BW_{Test}]$$

where *Abs( )* is the absolute value. This produces a sample that includes regions 1, 2, 3, 4, 5, 6, 9, and 10 in Figure 1.

The intuition behind this shape is simple. Imagine a case where we use only one cutoff, for example test score. We would then compare those above and below the cutoff with GPA values ranging from 0 to 4, creating a fuzzy discontinuity. Now consider the opposite approach, in which we would compare those within a small bandwidth across GPA, without regard for test score. Combining these leads to the L-Shaped region in Figure 1, where the relevant sample are those within a traditional RD bandwidth of either cutoff.

One could also conceive of a similar specification where we only compare those near the origin, eliminating observations that are close to one cutoff and far from the other. This throws away observations that are on either side of a valid, though fuzzy, RD cutoff by limiting the sample to those who are within the calculated bandwidth for both forcing variables. This creates the "Box" region in Figure 1, where the treatment group is now region 6, and the control groups are regions 2, 3, and 7. This eliminates students who were close to one threshold, but quite far from the other. We note that the same reasoning extends to the three-dimensional case as well, where the shape would be a cube.

Our preferred specification uses the two-dimensional "L-Shape" described here. In robustness checks we also estimate results using the two-dimensional "Box" shape, the three-dimensional "L-Shape" and the three-dimensional "Box" shape (i.e. a cube). In addition, within each of these sample frameworks, we test for effects of different specifications of the function *f( )* from Equation 2 by including different sets of interaction terms. We find that results are comparable across shapes and functional forms, and take our preferred specification as the most straightforward.

### 4.2 Smoothness and Manipulation Tests

We estimate our main model (Equation 1, using the functional form in Equation 2) on several variables to test for non-linearities in observable student characteristics across the cutoff in Appendix Table A.1. We estimate Equation 1 separately for each cohort and test for differences in gender, race, family wealth (AGI), whether the student attended the University of Georgia or Georgia Tech, ever received Pell, and

[24] This figure and framing are taken from Choi and Lee (2018).

credits earned by the end of the Spring 2010-11 semester. In all cases we find no evidence of discontinuities across the cutoff.

In Figure 2 we show density plots for each forcing variable and conduct analogous tests for bunching at the cutoffs. We find little evidence of manipulation of the forcing variables.[25] We note that for the SAT there is some evidence of a shift, but differences are slight. For that test, like the ACT and high school GPA, there is no feasible way for students to manipulate their scores or GPA in response to the legislation which came about several years later. Other work (Pope and Simonsohn, 2011; Goodman et al., 2018) finds bunching of SAT scores caused by students with scores just below round numbers being more likely to retake the test, creating lumpiness at these round cutoffs.[26] One can also observe jumps in the distribution at other factors of 100. We know of no other program or policy in Georgia that varies at an SAT score of 1200.

## 5. Results

### 5.1 Main Approach

In Table 3 we show local average treatment effects of earning the Zell Miller Scholarship compared with earning a reduced HOPE Scholarship. Our main specification is taken from Equation 1 using the functional form in Equation 2, which includes indicators for being above the HS GPA and SAT/ACT score cutoffs (Above Cutoffs), allows both forcing variables (HS GPA and SAT/ACT score) to take different slopes above and below the cutoff, and includes an interaction between the two forcing variables (creating a plane) which also can also take different slopes above and below the cutoff. This main specification takes the "L-Shape" described above as the range of possible values. It is also conditional on being above the college GPA cutoff.

The first column of Table 3 shows the likelihood of receiving Zell conditional on having been enrolled in the Fall of 2011-12, as we cannot observe scholarships for those not enrolled. We take this as a proximate first-stage estimate. We find that being just above both cutoffs (row 1) increased the likelihood of receiving Zell by 74 percentage points.[27] Column 2 shows that this translates to an average of $334 in

[25] We show SAT and ACT separately because they are scaled differently.
[26] We do not adjust our estimation strategy to account for bunching in test scores or GPA (Barreca et al, 2016).
[27] To investigate why this 74% number is not higher, we perform a misclassification exercise in which we tabulated predicted Zell Miller treatment versus actual Zell Miller treatment using the sample from the Zell column of Table 3. Noting that our tabulation is over all students in this sample and is not local to the cutoffs, we find that 91% of students are correctly classified (meaning those not predicted to receive Zell don't and those predicted to receive Zell do). Among those who are not correctly classified, most (77%) are predicted to receive Zell, but do not. We do not know why these students do not receive Zell, though it is possible they did not re-apply, fill out the required financial aid forms, or make satisfactory academic progress. The remainder (23%) of misclassified students are not predicted to receive Zell, but do. Of these students, the vast majority are over the HS GPA cutoff but not the test score threshold. Some number of these students may have received a Zell Miller Scholarship by being valedictorian or

additional merit-based aid per semester.[28] Taken as a percentage of the mean in the sample, this translates to roughly 12% less merit aid per semester on average at the cutoff. Scaling up to a 100 percent difference would imply a $452 per semester decrease, or close to 17 percent loss in funding, which is consistent with projected figures.[29]

In column 3 we show differences in enrollment in the first full semester after the policy change, the fall of the 2011-12 academic year.[30] We find that the point estimate is very close to zero. While our power does not allow us to detect very small effects, our estimate rules out an increase of enrollment of more than one percentage point. It is important to note here that the dropout rate (between Spring of 2010-11 and Fall of 2011-12) for all students within our bandwidth around the cutoff for both cohorts is only 2 percent. This highlights the implications of merit-based aid programs like this one. By targeting high achieving students, aid is given to those who have very high persistence rates conditional on enrollment. In other words, these students are not very likely to be price sensitive.

Column 4 repeats this exercise with four-year graduation as the outcome.[31] The baseline four year graduation rate, including those who did and did not get Zell, is 56 percent. Again acknowledging power, we do not find evidence of an effect of not earning Zell Miller (in the treatment year) on graduation.[32] We rule out graduation effects greater than approximately 4 percentage points.

Given that we see little effect of aid loss, we ask whether the loss in funding is made up with other forms of aid. We categorize four avenues through which students can compensate for the funding loss: 1) loans; 2) other grant aid; 3) work; or 4) family resources. We can test for the first two responses in our data, but we do not observe earnings and thus cannot test for the third. We note that Carruthers and Özek (2016) show that for those who lost Tennessee's HOPE scholarship in its entirety, only a small portion of the funding loss was made up through increased earnings by students. Hence, we expect increases in student earnings will not be large for students in our sample, who are both higher ability and wealthier on average. We know of no way to observe the fourth mechanism, but rather define it as any funding not coming from the former three.

In columns 5 and 6 of Table 3 we re-estimate our main specification for those students we observe enrolled in the Fall of the 2011-12 academic year using grant and loan aid for those who did not enroll,

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salutatorian of their high school graduating class, which we do not observe in the data. We are unable to specify the exact reason they received the scholarship, however.

[28] As noted in Footnote 9, the data provider indicated that HOPE+Zell dollar amount variable is less reliable; results using this variable should thus be interpreted accordingly.

[29] This is of the same magnitude as the $459 difference in Zell versus HOPE for students at the University of Georgia and Georgia Tech.

[30] Students who leave the University System of Georgia after the Spring semester would be considered to be not enrolled.

[31] For the 2009 (2010) cohort, this is defined as having graduated during or before Spring 2012-13 (2013-14).

[32] Note that this does not necessarily imply that students initially earning a Zell Miller Scholarship kept it through the entirety of schooling. Students may lose the scholarship if they fall below the 3.3 college GPA cutoff at a checkpoint. We do not model this as it entails an endogenous effort response by the student which we cannot take as exogenous.

though from columns 3 and 4 we do not observe enrollment or graduation differences across treatment and control groups near the cutoff. We find no meaningful differences in loans in column 5 or in grants in column 6.[33] Finally, in column 7 we display total grants, which includes HOPE/Zell money as well as grants.[34]

We next examine whether the impact of aid loss is heterogenous across students of different wealth. For example, we might expect the loss of aid to have a larger impact on poorer, and thereby more income constrained, students. Yet, while wealthier families may be able to absorb the aid loss more easily, poorer students are eligible for other need-based grants, and are eligible for subsidized federal student loans, effectively allowing them to borrow at a reduced price. In Table 4 Panel A we re-estimate our main specification and include an interaction with family AGI, conditional on observing AGI from the FAFSA.[35] For loans and grants, we first confirm that the main effect of AGI is in the expected direction and do find that students with higher family AGI take out fewer loans and receive less in non-HOPE/Zell grant aid. We find little evidence, though, that the partial financial aid loss had differential effects on persistence or graduation for students with different family incomes.[36]

The results in Table 4 also find no statistically meaningful effects on borrowing or grant aid for those above the cutoff by AGI (or in the main effect for those with an AGI of zero). Examining means for the dependent variable, at the bottom of the table, shows that students near the cutoff received approximately $1,300 in loans and $900 in other grant aid in the Fall of the 2011-12 school year, suggesting that these students were not facing binding capital constraints.

We run a similar specification in Table 4 Panel B but include an interaction of ever receiving the Pell Grant. The only outcome for which we find a statistically significant coefficient is enrollment, which is negative and yields the unintuitive result that Pell recipients above the cutoff are less likely to enroll than Pell recipients below the cutoff—we would not have expected the additional Zell money to decrease enrollment. There is no difference in enrollment probability between Pell recipients above the cutoff and non-Pell recipients above the cutoff (-0.2+0.2).

## 6. Robustness

To ensure that our results are not simply an artifact of modeling decisions, we conduct a host of robustness

[33] We omit results for work study as this is only a small fraction of the average student's aid.
[34] The coefficient in column 7 is not exactly the sum of columns 2 and 6 because the baseline sample for column 2 has a different number of observations than that for column 6 because a) we exclude observations from Georgia State University in column 2 and 7, and b) the bandwidths also vary between the columns.
[35] In this regression, we do not control for Pell receipt.
[36] We also ran this replacing the linear version of AGI with bins of AGI. None of the interaction terms were statistically significant with the exception of Above Cutoff*30-60k (where 0-30K is the reference category), which was -0.3. We do not have a good explanation for why enrollment is lower in the 30-60k group than the 0-30k group, however.

checks. Overall, we find that our results are robust to a number of different bandwidths, samples, and specifications. We describe one robustness table and a set of graphs below, and present remaining robustness checks and explanations in the Appendix.

Table 5 shows the main set of robustness checks. The table is organized such that each column corresponds to an outcome and each row corresponds to a robustness check. Each cell shows the *Above Cutoffs* coefficient from a separate regression (49 regressions in total). Panel A uses the L-Shape bandwidth. For convenience, the first row of this Panel reproduces the results from the preferred specification (Table 3). The second row is the same, except that the sample is not restricted to those above the College GPA cutoff. Because the contrast is weaker, first stage Zell estimates are smaller in this specification. The HOPE+Zell estimate is smaller, but still statistically significant. The results for enrollment, graduation, loans, and grants are similar, except that the negative effect on grants is larger and statistically significant. This may be the result of students taking fewer credit hours (it is possible that students above the cutoff might be incentivized to take fewer credits relative to those below the cutoff for the reasons mentioned in section 2.2), and thus receiving less in aid. Our data do not allow us to observe credits in each term, thus we cannot disentangle the relationship.

The next panel repeats Panel A, but uses the Box Bandwidth, described in Section 4.1.1. Because the sample is smaller, standard errors are larger. Results are similar overall. The loan and grant results are larger for the full sample and are both significant. Panel C extends the model to three dimensions, or a 3-dimensional RD. Equation 2 is generalized to also include college GPA, and includes all two-way interactions, as well as the three-way interaction. Results are similar to those in Panel A, but are more noisily estimated. Larger significant dollar amounts in the full sample are observed for HOPE+Zell and grants. Finally, Panel D checks robustness to a particular feature of the data, particularly that in some cases individuals are coded as having received HOPE (Zell), but the corresponding financial aid variable indicates that they received $0 of HOPE (Zell). We exclude such cases, otherwise repeating the specification in Panel A.[37] Results are extremely similar to the first row of Panel A, but the HOPE+Zell estimate is somewhat larger.

We also display the data graphically, in a similar spirit to the approach used in Jacob and Lefgren (2004) and Matsudaira (2008). In particular, in Appendix Figures A.1 through A.3, we display one-dimensional RD plots conditional on the two other variables.[38] Each set of three plots corresponds to one outcome. The left panel has Test Score as the x-axis with (centered) HS GPA and College GPA both being

[37] This issue can also arise if the financial aid data is not matched to the individual.
[38] In practice, we first exclude observations that are not over the first cutoff, then use rdbwselect command (with the mserd bandwidth selection procedure—see Calonico, Cattaneo, and Titiunik, 2014) from the rdrobust package in Stata (Calonico, Cattaneo, Farrell and Titiunik, 2017) to obtain the bandwidth without using covariates. We use the rdplot package to produce the figures.

at or above zero. The middle and right panels are for HS GPA and College GPA, respectively, with the sample conditional on the other two. There is a large discontinuity for Zell Miller Scholarships, particularly using the Test and HS GPA running variables. This same pattern is observed for total merit aid (HOPE+Zell). With the occasional exception, the other outcomes generally do not show visual evidence of a discontinuity. Taken together, we conclude that results are not specific to one parameterization or another.

The final approach we take is similar in spirit to, though a more rigorous treatment of, the multi-dimensional RD case. Building on more recent work by Cattaneo et al. (2018), we estimate the effect of being over the cutoff at multiple locations along each treatment boundary, allowing us to observe different local average treatment effects in the case that effects are heterogenous across these dimensions.[39] For example, one could envision a differential effect of losing aid for a student with a high school GPA of 4.0 and an SAT score near the 1200 cutoff, compared to a student with an SAT score of 1600, but who has a GPA near the cutoff of 3.7.

Results are shown in Table 6. Beginning with column 1, we show that the impact of crossing the cutoff at each point on the likelihood of receiving Zell is positive and statistically significant, with the largest effect (0.89) for those on either side of the high school GPA cutoff with SAT/ACT scores one standard deviation above the mean and the smallest effect (0.57) for those at the SAT/ACT cutoff with high school GPAs near 3.85. Positive and statistically significant effects for merit aid (HOPE + Zell) are observed for two of the three cutoffs. None of the coefficients on enrollment or graduation are statistically significant, however the standard errors are larger than in previous tables, making it more difficult to observe potentially small effects. Loans and grants are also noisily estimated; there is evidence that, at two locations, grants decreased for students above the cutoffs.

## 7. Policy Implications and Conclusions

The implementation of Georgia's Zell Miller Scholarship with retroactive eligibility, combined with a simultaneous reduction in the level of benefits available under the well-known HOPE Scholarship Program, provides a unique natural experiment to examine how students respond to an exogenous loss of substantial, but not total, financial aid mid-college. Using regression-discontinuity to compare students just above and below the Zell Miller eligibility cutoffs, we find little evidence of impacts on student enrollment, graduation, or borrowing. There are several likely reasons for this.

First, Zell Miller recipients, or those near the cutoff for earning it, are high-performing students in their second or third year of college. We might expect these students to be less price-sensitive than their

[39] To implement this approach, we use the rdmulti Stata package (Cattaneo, Titiunik and Vazquez-Bare, 2018). No covariates are used. The functional form of the running variables differs compared to our two-dimensional approach.

peers because they would be likelier to graduate from college even in the absence of merit aid, and because their expected benefit from a degree would likely far outweigh their expected cost from two additional years of college. Second, the SAT/ACT requirement results in a sample at the cutoff clustered at the state's two highest-ranked research institutions, University of Georgia and Georgia Tech. Students at these institutions tend to come from families with higher-than average financial resources, a fact borne out in descriptive statistics. Therefore, these students would have higher-than-average family resources to draw upon when their aid is reduced. In many cases, the lost aid may have simply represented additional support families can provide, rather than the tipping point between being able to afford college or not.

There are several limitations to our study. First, the size of the treatment is relatively modest; this leads to less power than would be ideal, lessening our ability to detect small effect sizes or tightly-estimated zeroes. The second is the generalizability of our findings. We cannot infer from our data how the new requirement may have affected students with lower achievement levels, such as those closer to the HOPE high school and college GPA cutoffs of 3.0. We also do not infer how the change may have affected students just enrolling in college, or at the extensive margin. Given that the additional costs for these students would be higher (four more years of college) it is possible they would be more price-responsive than enrolled students.

While the magnitude of the funding loss examined here is relatively small compared to the complete loss of funding in Carruthers and Özek (2016), it is of the same magnitude as that found in several other financial aid papers.[40] For example, Denning and Jones (2019) find that increased eligibility for federal loans leads to an increase in $131 in borrowing for the fall semester. In an experiment, Marx and Turner (2019) present students with different offers of financial aid, resulting in an increase of $282 of loan take-up for the school year (not just the fall semester). In another experiment, Barr, Bird, and Castleman (2017) text students with the aim of encouraging them to make informed and active borrowing decisions; those receiving the texts borrowed $90 less in unsubsidized Stafford loans, with a decrease of $242 among those receiving the texts before the priority financial aid filing deadline. Two of the above studies find educational effects. The experiment in Marx and Turner (2019) led to an increase in credits and GPA. The texting in Barr, Bird, and Castleman (2017) resulted in marginal students dropping out one semester earlier. Acknowledging that the amount borrowed among the treated is very large in Marx and Turner (2019), the average amount borrowed in both papers is similar to ours. Importantly, though, the margin that we study is very different: both papers focus on community college students, while we focus on very high-achieving students at research universities.

[40] We note that these other financial aid papers rely on treatments—information, texting, and higher loan eligibility—that may (and ultimately do) lead to changes in financial aid, as opposed to a direct change in financial aid, as is the case in our paper and in Carruthers and Özek (2016).

Previous research examining financial aid loss due to institutional ineligibility finds, similar to our results, that returning students, and those with stronger academic backgrounds, tend to be unaffected. Darolia (2013) uses dynamic RDD to examine enrollment effects at institutions that lose eligibility to disburse federal aid due to high federal loan default rates. He finds large enrollment declines at for-profit institutions but that they are concentrated among new students. Similar to our results, he finds no declines among students already in college. Cellini, Darolia and Turner (2016) find that Pell Grant recipients are particularly affected by the loss in federal aid eligibility. Failing to complete the FAFSA can lead to access to smaller amounts of financial aid. Page, Castleman, and Meyer (2019) text high school students to encourage FAFSA completion and find that this induces students to complete their FAFSA earlier and matriculate at higher rates. Similarly, Castleman and Page (2017) use experimental methods to evaluate a texting program encouraging freshman college students to renew their FAFSA and offering assistance. They find no significant effects on persistence for students who begin at four-year institutions and those with higher high school GPAs, likely because persistence rates for these students are already high.

The results presented here provide evidence that offering merit-based financial aid to the highest-achieving students, at least in magnitudes studied in this paper, may have little effect on their college-completion behavior once enrolled. This finding is in many ways a corollary to Dynarski's earlier work (2004) which found that merit aid programs with the least stringent eligibility requirements had the largest effects on student enrollment decisions. In this case, only students at the upper-end of the achievement distribution lost financial aid and the loss had little effect on their decision to remain in college, suggesting these high-achieving students are less responsive to changes in financial aid.

The results also suggest that merit-based aid renewal requirements could be adjusted to improve efficiency and equity. For example, most merit aid programs, including HOPE, include high stakes "all or nothing" eligibility thresholds in which students lose their full merit aid if they fall below certain (likely arbitrary) GPA cutoffs. Our results show that partial aid loss may have much less severe consequences on persistence and graduation. Thus, maintenance requirements could be structured on a sliding scale with, for example, a college GPA below 3.5 resulting in a 10 percent reduction, a 25 percent reduction below 3.3 and a 50 percent – rather than total – reduction in aid for students falling below 3.0. Such a structure could benefit students most likely to be on the margin of persisting in college by preserving at least partial tuition coverage. Similarly, GPA eligibility thresholds could be increased as students progress in college, or merit aid levels could be reduced for students in their third, fourth and fifth years. Our results indicate that high-performing students already well into their college careers are not overly price sensitive as they may already be "locked in" to college attendance. Reducing aid for these students could lower program costs with minimal effects on college outcomes.

Finally, this paper also provides evidence relevant to on-going policy debates regarding merit-based versus need-based aid. Georgia is one of the few states with no need-based scholarship program. Because high-achieving students are most likely to attend college, generous guarantees of full or close-to-full tuition may affect where students attend college but are unlikely to influence whether they attend or remain in college. In that sense, merit aid targeted only to the highest achieving students may represent an inefficient use of scholarship funds by focusing resources on the students already most likely to attend and finish college. The high bar for earning the full-tuition Zell Miller Scholarships, and particularly the SAT/ACT eligibility requirement, also appears to produce a recipient population that is wealthier and whiter than the overall population of Georgia college students. Need-based aid could provide an important supplement for broad-based merit aid in the state, particularly with the state's merit aid now even more strongly targeted to the highest achieving students.

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## Appendix – Additional Robustness Checks

First, in Appendix Table A.2, we repeat the main robustness check table, Table 5, but do not include covariates. Results are similar, with aid and loan coefficients increasing in magnitude in some cases. Next, Appendix Tables A.3-A.9 show versions of the main results as well as most robustness checks, but with different functional forms. Each outcome is displayed in its own table. Column 1 includes only main effects, while Column 2 instead allows the main effects to vary on either side of the cutoff. Column 3 adds to Column 2 interactions between the main effects.[41] Column 4 adds to column 2 indicators for being above the individual cutoffs.[42] Column 5 has everything in Columns 3 and 4. Column 3 is the same as in Table 5. Estimates generally get noisier across columns. With some exceptions, results, particularly in terms of statistical significance, are similar across columns. Appendix Table A.10 shows the Locations Approach, but not conditional on being above the college GPA cutoff. The Zell and HOPE+Zell coefficients are dampened, but the other variables are of the same magnitude. Finally, in Appendix Tables A.11 and A.12 we reproduce the main results, but estimating results for the 2009 and 2010 cohorts separately. Results, while noisier, are similar to those in Table 3.[43]

## Appendix – Additional Details on Locations Approach

Cattaneo et al.'s (2018) technique estimates effects at multiple points on each dimension and then averages effects. In practice, this is a data-intensive procedure that stretches our sample. That said, we can choose a smaller number of representative points and observe whether effects are heterogenous at different points in the GPA and SAT/ACT distribution, away from the origin cutoff. The assumption then is that if we do not observe differential effects at these points, it is unlikely that we would observe effects at all points between these locations and the origin. To find otherwise would suggest non-linear relationships, which we can think of no *a priori* reason to uncover. This approach does not rule out differential effects beyond these points away from the origin where our data are too sparse to reliably detect modest differentials. For example, there are few if any observations with perfect SAT scores and high school GPAs near 3.7.

[41] For the 2D case, this is *Test, Above Cutoff * HS GPA, Above Cutoff* and Test, Below Cutoff * HS GPA, Below Cutoff. The 3D case includes all two-way interactions and three way interactions, separate for above and below.

[42] We point out that including the indicators for being above the individual cutoffs complicates the interpretation of results; how to sum up coefficients on *Above Cutoffs* and the cutoff variables depends on which hypothesis one wants to test. We only present *Above Cutoffs* in this table; we do not consider the coefficients on these variable in discussion of the results in the text. For the main specification, only for Zell and HOPE Zell is the Above Test Cutoff variable statistically significant. Only for Zell is the Above HS GPA cutoff significant.

[43] Results have quite large standard errors for the Locations approach separate by cohort. Most of the HOPE+Zell coefficients are not statistically significant for the 2010 cohort. A few other coefficients are statistically significant, but again, have very large standard errors. Similarly, when splitting other tables by cohort, standard errors are larger, and in some cases we find statistically significant results, which we do not find to be significant when combined.

To be concrete, we estimate the effect of crossing the SAT/ACT cutoff for those with a high school GPA of 3.7 (the origin) and those with a high school GPA of 3.85. We then repeat the exercise for crossing the high school GPA cutoff with an SAT (ACT) score of 1200 (26) – the origin – and then for those with an SAT (ACT) score one standard deviation above the origin. These points are displayed graphically in Figure A.4. We present results conditional on being above the college GPA, with unconditional results in the Appendix.

# Tables

Table 1: Summary Statistics

| | No HOPE | HOPE | All |
|---|---|---|---|
| Demographic Variables | | | |
| Male | 0.49 | 0.39 | 0.43 |
| | (0.50) | (0.49) | (0.49) |
| White | 0.47 | 0.67 | 0.59 |
| | (0.50) | (0.47) | (0.49) |
| Black | 0.38 | 0.16 | 0.25 |
| | (0.49) | (0.37) | (0.44) |
| Hispanic | 0.05 | 0.05 | 0.05 |
| | (0.22) | (0.22) | (0.22) |
| Other Race | 0.10 | 0.11 | 0.10 |
| | (0.29) | (0.31) | (0.31) |
| Credits by 20114 | 32.46 | 43.18 | 38.77 |
| | (18.30) | (19.55) | (19.76) |
| SAT $\geq$ ACT | 0.71 | 0.71 | 0.71 |
| | (0.45) | (0.45) | (0.45) |
| UGA/Tech | 0.05 | 0.28 | 0.19 |
| | (0.23) | (0.45) | (0.39) |
| Ever Pell | 0.58 | 0.45 | 0.50 |
| | (0.49) | (0.50) | (0.50) |
| AGI | 64857.92 | 90114.02 | 79977.50 |
| | (64767.87) | (85188.37) | (78620.69) |
| Forcing Variables | | | |
| Test | -1.23 | -0.46 | -0.78 |
| | (0.85) | (0.90) | (0.96) |
| HS GPA | 2.76 | 3.48 | 3.19 |
| | (0.49) | (0.34) | (0.54) |
| College GPA | 2.20 | 3.15 | 2.76 |
| | (0.81) | (0.63) | (0.85) |
| Outcome Variables | | | |
| Zell (20122) | 0.00 | 0.13 | 0.08 |
| | (0.03) | (0.33) | (0.27) |
| Enrolled in 20122 | 0.80 | 0.93 | 0.88 |
| | (0.40) | (0.25) | (0.33) |
| Grad 4 Yr | 0.06 | 0.32 | 0.21 |
| | (0.23) | (0.47) | (0.41) |
| Loans (20122) | 2227.43 | 1545.01 | 1799.85 |
| | (2489.07) | (2149.57) | (2305.99) |
| Grants (20122) | 1132.08 | 941.52 | 1012.68 |
| | (1437.84) | (1374.62) | (1401.58) |
| Observations | 25081 | 35930 | 61011 |

Notes: This table presents summary statistics. Column 3 is after all sample restrictions described in the text except for having HOPE or Zell in Spring 2010-11. Columns 1 and 2 are a subset, with column 1 not having received HOPE in Spring 2010-11 and column 2 having received it. *Credits by 20114* refers to the number of credits, including transfer credits, earned by the end of Spring 2010-11. *SAT* $\geq$ *ACT* indicates that the SAT score was greater than or equal to the ACT score if the student took both tests, or if the student took only the SAT. *UGA/Tech* is an indicator for attending University of Georgia or Georgia Institute of Technology in Spring 2010-11. *Ever Pell* is an indicator for having received any Pell money at any time in the data. *AGI* is adjusted family income, and is conditional on filling out this element on the FAFSA; it is the average AGI up to Spring 2010-11. *Test* is the standardized SAT/ACT variable, and takes the higher of the two tests. *College GPA* is measured at the end of Spring 2010-11. *20122* refers to Fall 2011-12. *Grad 4 Yr* is graduated within 4 years. *Loans* and *Grants* are the amount of loans and grants, excluding HOPE, Zell, and HOPE grants, received in Fall 2011-12.

Table 2: Funding Dollars

| | HOPE Losers | HOPE Persisters | Zell |
|---|---|---|---|
| Loans | 984.98 | 345.71 | 230.53 |
| Grants | -108.14 | -100.57 | -97.81 |
| Work Study | 6.65 | 3.56 | 3.99 |
| HOPE | -2648.07 | -728.85 | -3727.36 |
| Zell | 0.00 | 0.00 | 3276.45 |
| Total | -1764.07 | -480.15 | -314.19 |
| Observations | 7488 | 18301 | 4055 |

Notes: This table shows differences in the average amount funding sources students received between the Spring 2010-11 and the Fall 2011-12 semesters for the following categories: Loans, Grants (excluding HOPE and Zell and HOPE grants), Work Study, HOPE, and Zell. The difference is constructed by subtracting Spring from Fall, meaning that positive amounts indicate a greater amount in the Fall semester.The sample is split into three groups: *HOPE Losers*, who had HOPE in Spring 2010-11, but lost it in Fall 2011-12; *HOPE Persisters*, who had HOPE in both semesters; *Zell*, who had HOPE in Spring 2010-11 and Zell in Fall 2011-12. HOPE status is taken from the administrative data; it happens that someone is considered as having received HOPE while not receiving any HOPE money. These cases are included. Due to missing data, students who attended Georgia State University during at least one of the two semesters in consideration are omitted. Students who enroll in the Spring, but do not persist to the Fall semester are excluded.

Table 3: L-Shape Bandwidth, Conditional on Being Above College GPA Cutoff

| | (1) Zell | (2) Hope+Zell | (3) Enrolled | (4) Grad 4 Yr | (5) Loans | (6) Grants | (7) Total Grants |
|---|---|---|---|---|---|---|---|
| Above Cutoffs | 0.74*** | 334.37*** | -0.01 | -0.00 | 60.30 | -47.69 | 301.86*** |
| | (0.02) | (31.36) | (0.01) | (0.02) | (88.72) | (61.50) | (72.69) |
| Test, Below | -0.03 | -56.31 | 0.00 | 0.00 | -208.87 | 132.71 | 14.07 |
| | (0.06) | (84.88) | (0.02) | (0.04) | (178.70) | (179.12) | (209.27) |
| Test, Above | 0.02 | -72.09** | -0.01 | -0.06** | -327.14*** | 41.69 | -26.29 |
| | (0.01) | (29.57) | (0.01) | (0.02) | (95.21) | (55.31) | (67.98) |
| HS GPA, Below | 1.50*** | 1650.98*** | 0.32 | -0.33 | -1647.05 | 481.59 | 1264.30 |
| | (0.28) | (489.42) | (0.46) | (0.50) | (1462.85) | (1044.44) | (1392.17) |
| HS GPA, Above | 0.11 | -623.14*** | -0.02 | 0.22*** | -379.00 | 499.26** | -129.11 |
| | (0.07) | (119.32) | (0.03) | (0.08) | (309.58) | (207.78) | (254.12) |
| Test*HS GPA, Below | 3.18*** | -710.75 | -0.55 | -0.54 | 693.60 | -772.21 | -2989.78 |
| | (1.23) | (2144.94) | (1.92) | (1.29) | (4003.17) | (3961.30) | (5684.50) |
| Test*HS GPA, Above | 1.18*** | 1669.92*** | 0.08 | -0.11 | 482.59 | 639.71 | 2444.83*** |
| | (0.29) | (359.88) | (0.08) | (0.18) | (785.07) | (693.95) | (843.22) |
| N | 3480 | 4647 | 4534 | 6222 | 6008 | 4729 | 4335 |
| R2 | 0.69 | 0.62 | 0.01 | 0.16 | 0.04 | 0.39 | 0.42 |
| Test BW | 0.41 | 0.56 | 0.62 | 0.85 | 0.75 | 0.55 | 0.53 |
| HS GPA BW | 0.08 | 0.11 | 0.05 | 0.08 | 0.12 | 0.10 | 0.10 |
| Term | 20122 | 20122 | 20114 | 20114 | 20122 | 20122 | 20122 |
| Y Mean | 0.46 | 2711.03 | 0.98 | 0.56 | 1108.04 | 788.78 | 3504.01 |
| Covariates | x | x | x | x | x | x | x |

Notes: This table, which uses the L-shape bandwidth and the functional form of equation 2 in the text, has the following dependent variables: *Zell* (received Zell in Fall 2012), *Hope+Zell* (the combined amount of HOPE and Zell received in Fall 2012), *Enrolled* (enrolled in Fall 2012), *Grad 4 Yr* (graduated in 4 years), *Loans* (amount of loans received in Fall 2012), *Grants* (the amount of grants received in Fall 2012, excluding HOPE and Zell), and *Total Grants*, the sum of Hope+Zell money and grants. Each column is for a separate dependent variable. The variable of interest, *Above Cutoffs*, is an indicator for being above both thresholds. *Test, Below* and *Test, Above* are equivalent to the test score variable, except *Test, Below* is 0 where the test score is greater or equal to 0, and *Test, Above* is 0 where the test score variable is less than 0. *HS GPA, Below* and *HS GPA, Above* are analogously defined. Interactions between *Test, Below* and *HS GPA, Below*, as well as *Test, Above* and *HS GPA, Above* are also included. The test and HS GPA bandwidths are listed at the bottom of the table, as is the mean of the dependent variables over the sample used in the corresponding regression. Students from Georgia State University are excluded from the HOPE+Zell and Total Grants columns. Covariates are included, and robust standard errors are used. * 0.10, ** 0.05, *** 0.01.

Table 4: L-Shape Bandwidth, Conditional on Being Above College GPA Cutoff; with AGI Interaction

*Panel A: AGI Interaction*

| | (1) Zell | (2) Hope+Zell | (3) Enrolled | (4) Grad 4 Yr | (5) Loans | (6) Grants | (7) Total Grants |
|---|---|---|---|---|---|---|---|
| Above Cutoffs | 0.72*** | 294.30*** | -0.01 | -0.01 | 98.63 | -51.35 | 292.25** |
| | (0.02) | (42.89) | (0.01) | (0.03) | (110.84) | (112.66) | (128.31) |
| AGI | -0.00 | 4.68 | -0.00 | 0.01 | -236.41*** | -515.39*** | -500.18*** |
| | (0.01) | (11.87) | (0.00) | (0.01) | (29.21) | (57.16) | (60.30) |
| Above Cutoffs*AGI | 0.02** | 10.72 | 0.01 | 0.01 | 3.73 | 10.41 | 18.00 |
| | (0.01) | (20.61) | (0.00) | (0.01) | (44.06) | (77.34) | (81.02) |
| N | 3082 | 3645 | 4075 | 4741 | 5040 | 4062 | 3592 |
| R2 | 0.70 | 0.61 | 0.01 | 0.16 | 0.04 | 0.18 | 0.29 |
| Test BW | 0.42 | 0.59 | 0.65 | 0.69 | 0.76 | 0.52 | 0.53 |
| HS GPA BW | 0.07 | 0.08 | 0.05 | 0.10 | 0.12 | 0.12 | 0.10 |
| Term | 20122 | 20122 | 20114 | 20114 | 20122 | 20122 | 20122 |
| Y Mean | 0.45 | 2663.18 | 0.98 | 0.56 | 1300.51 | 897.07 | 3581.91 |
| Covariates | x | x | x | x | x | x | x |

*Panel B: Ever Pell Interaction*

| | (1) Zell | (2) Hope+Zell | (3) Enrolled | (4) Grad 4 Yr | (5) Loans | (6) Grants | (7) Total Grants |
|---|---|---|---|---|---|---|---|
| Above Cutoffs | 0.75*** | 346.00*** | 0.00 | -0.00 | 29.40 | -69.77 | 305.69*** |
| | (0.02) | (32.94) | (0.01) | (0.02) | (95.43) | (58.47) | (70.43) |
| Ever Pell | -0.00 | -59.09*** | 0.02** | -0.07*** | 452.41*** | 1629.23*** | 1632.16*** |
| | (0.01) | (22.67) | (0.01) | (0.02) | (65.91) | (52.94) | (61.70) |
| Above*Ever Pell | -0.03 | -36.75 | -0.02*** | 0.00 | 92.64 | 66.65 | -12.08 |
| | (0.02) | (37.87) | (0.01) | (0.02) | (97.22) | (83.80) | (99.20) |
| N | 3480 | 4647 | 4534 | 6222 | 6008 | 4729 | 4335 |
| R2 | 0.69 | 0.62 | 0.02 | 0.16 | 0.04 | 0.39 | 0.42 |
| Test BW | 0.41 | 0.56 | 0.62 | 0.85 | 0.75 | 0.55 | 0.53 |
| HS GPA BW | 0.08 | 0.11 | 0.05 | 0.08 | 0.12 | 0.10 | 0.10 |
| Term | 20122 | 20122 | 20114 | 20114 | 20122 | 20122 | 20122 |
| Y Mean | 0.46 | 2711.03 | 0.98 | 0.56 | 1108.04 | 788.78 | 3504.01 |
| Covariates | x | x | x | x | x | x | x |

Notes: Panel A is the same as Table 3 except that it includes an AGI (adjusted gross income) main effect and an AGI-Above Cutoffs interaction (and does not control for Ever Pell). Panel B includes an interaction between ever receiving Pell and Above-Cutoffs. For both panels, only the the two main effects and interactions are displayed for brevity. See Table 3 for additional notes. * 0.10, ** 0.05, *** 0.01.

Table 5: Robustness Checks

| | Zell | HOPE+Zell | Enrolled | Grad 4 Yr | Loans | Grants | Total Grants |
|---|---|---|---|---|---|---|---|
| *Panel A: L-Shape Bandwidth* | | | | | | | |
| College GPA≥0 | 0.74*** | 334.37*** | -0.01 | -0.00 | 60.30 | -47.69 | 301.86*** |
| | (0.02) | (31.36) | (0.01) | (0.02) | (88.72) | (61.50) | (72.69) |
| Full Sample | 0.50*** | 188.44*** | 0.01 | -0.01 | 76.24 | -110.47* | 70.62 |
| | (0.02) | (45.73) | (0.01) | (0.02) | (92.90) | (65.89) | (86.65) |
| *Panel B: Box Bandwidth* | | | | | | | |
| College GPA≥0 | 0.76*** | 316.26*** | -0.02 | -0.04 | 147.44 | -60.47 | 246.41* |
| | (0.04) | (52.91) | (0.01) | (0.04) | (144.06) | (106.72) | (136.16) |
| Full Sample | 0.49*** | 183.51* | 0.02 | -0.03 | 309.83** | -263.14** | -137.00 |
| | (0.04) | (94.63) | (0.02) | (0.04) | (149.62) | (116.64) | (164.18) |
| *Panel C: 3D RD* | | | | | | | |
| L-Shape Bandwidth | 0.60*** | 362.08*** | -0.01 | -0.01 | 16.13 | -66.13 | 252.65** |
| | (0.03) | (43.99) | (0.01) | (0.03) | (118.91) | (80.07) | (105.66) |
| Box Bandwidth | 0.53*** | 409.67*** | -0.03 | -0.07 | 255.73 | -329.33* | 25.19 |
| | (0.11) | (102.77) | (0.02) | (0.06) | (264.80) | (174.41) | (246.26) |
| *Panel D: Exclude $0* | | | | | | | |
| L-Shape BW; Col. GPA≥0 | 0.73*** | 413.70*** | -0.01 | 0.00 | 62.46 | -48.63 | 376.08*** |
| | (0.02) | (26.58) | (0.01) | (0.02) | (90.40) | (61.30) | (72.06) |

Notes: This table shows robustness checks. Each coefficient is the *Above Cutoffs* coefficient from a different regression. Each column corresponds to a different outcome. Panel A uses the L-Shape bandwidth. The first set of coefficients restrict the sample to those with centered college GPA above 0; they are a reproduction of the *Above Cutoffs* estimates from Table 3. The second set of estimates in Panel A does not make the centered college GPA restriction. Panel B is the same as Panel A, but uses the Box bandwidth. Panel C shows results for a 3D RD, with the first set of estimates using the L-Shape bandwidth and the second set using the Box bandwidth. Panel D is the same as the first set of estimates in Panel A, but restricts individuals who were coded as receiving HOPE in Spring 2011 or HOPE (Zell) in Fall 2012, but also coded as receiving $0 of HOPE (Zell) money in that semester.

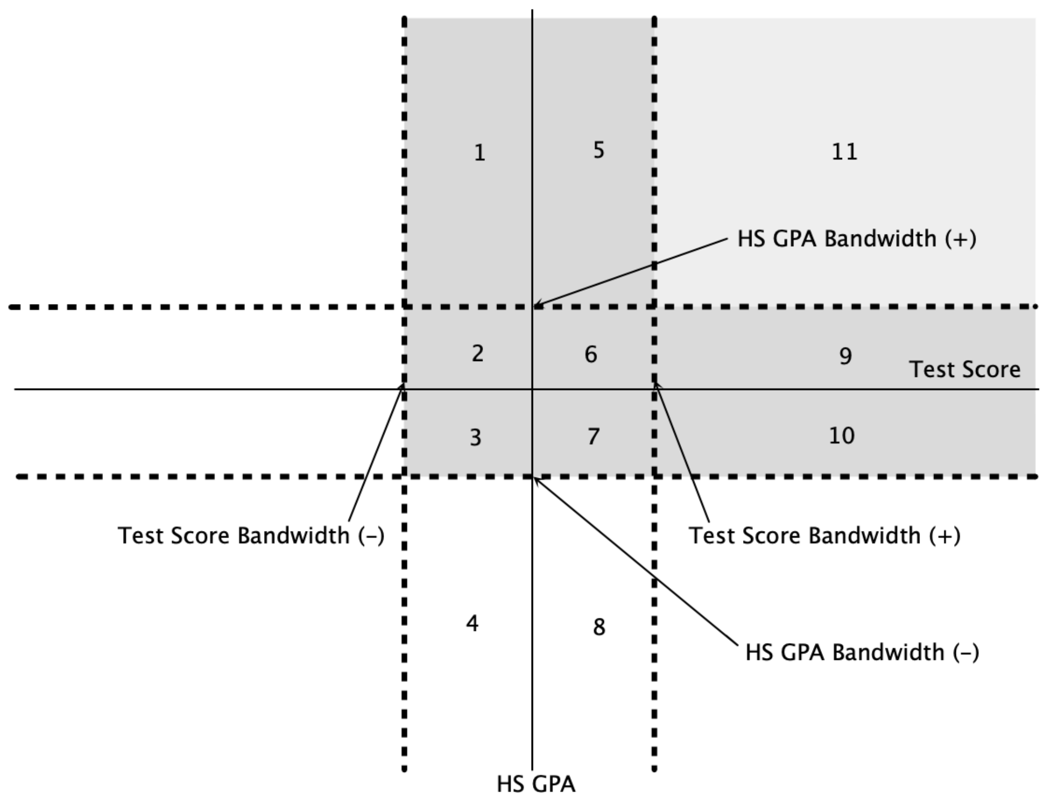
Table 6: Locations Approach, Conditional on Being Above College GPA Cutoff

| | (1) Zell | (2) HOPE+Zell | (3) Enrolled | (4) Grad 4 Yr | (5) Loans | (6) Grants | (7) Total Grants |
|---|---|---|---|---|---|---|---|
| Cutoff 1 - (0; .15) | 0.57*** | 135.03 | -0.00 | -0.06 | -6.39 | -342.37** | -178.79 |
| | (0.05) | (90.00) | (0.02) | (0.05) | (152.32) | (148.20) | (170.16) |
| Cutoff 2 - (0; 0) | 0.66*** | 245.15** | -0.01 | -0.03 | 38.51 | -262.29* | 68.76 |
| | (0.05) | (103.49) | (0.01) | (0.05) | (164.88) | (154.83) | (172.80) |
| Cutoff 3 - (1; 0) | 0.89*** | 394.03* | 0.00 | -0.13 | -469.73 | 746.48 | 1134.20** |
| | (0.05) | (207.20) | (0.01) | (0.11) | (445.63) | (501.30) | (548.79) |
| Cutoff 1 BW | 0.28 | 0.52 | 0.61 | 0.52 | 0.79 | 0.50 | 0.51 |
| Cutoff 2 BW | 0.44 | 0.54 | 0.50 | 0.53 | 0.78 | 0.41 | 0.51 |
| Cutoff 3 BW | 0.28 | 0.26 | 0.31 | 0.36 | 0.30 | 0.24 | 0.25 |
| Cutoff 1 N | 947 | 2700 | 3851 | 3084 | 5657 | 2830 | 2651 |
| Cutoff 2 N | 2698 | 3348 | 3523 | 3793 | 6054 | 2306 | 3114 |
| Cutoff 3 N | 307 | 279 | 413 | 520 | 389 | 245 | 249 |
| Term | 20122 | 20122 | 20114 | 20114 | 20122 | 20122 | 20122 |

Notes: This table, which uses the locations approach described in Section 6, has the following dependent variables: *Zell* (received Zell in Fall 2012), *Hope+Zell* (the combined amount of HOPE and Zell received in Fall 2012), *Enrolled* (enrolled in Fall 2012), *Grad 4 Yr* (graduated in 4 years), *Loans* (amount of loans received in Fall 2012), *Grants* (the amount of grants received in Fall 2012, excluding HOPE and Zell), and *Total Grants*, the sum of Hope+Zell money and grants. Each coefficient is an estimate for a different part of the joint distribution of test score and HS GPA. *(0; 0.15)* refers to a test score of 0 and a HS GPA of 0.15, both of which are centered. The sample is conditional on being above the college GPA cutoff. * 0.10, ** 0.05, *** 0.01.

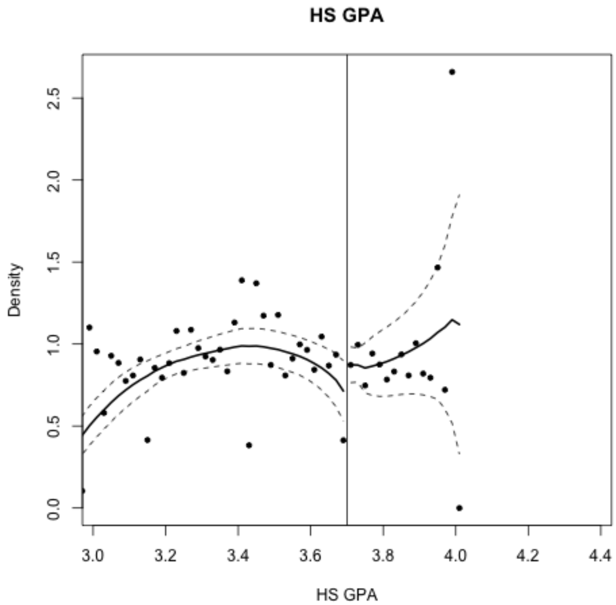
# Figures

Figure 1: Bandwidth Illustration

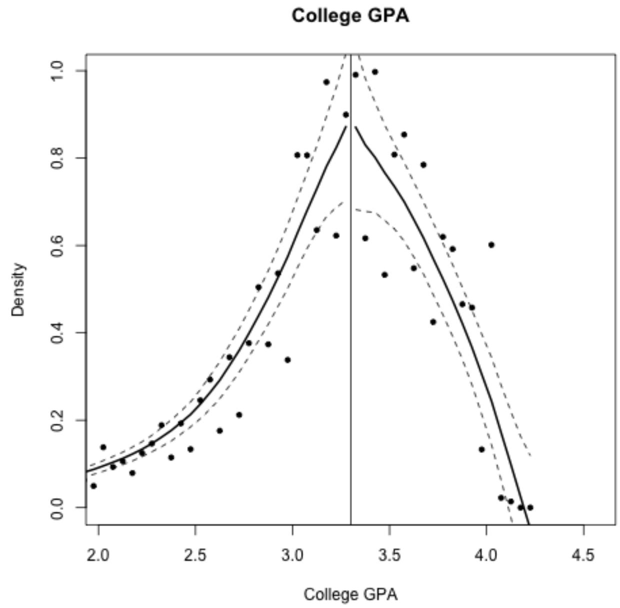



Notes: This figure illustrates the two-dimensional regression discontinuity design. The x-axis and y-axis are the test score and HS GPA, respectively; both are centered at their respective thresholds. The vertical dashed lines are the bandwidths for test score: "Test Score Bandwidth (+)" and "Test Score Bandwidth (-)," and the horizontal dashed lines are the bandwidths for HS GPA: "HS GPA (+)" and "HS GPA (-)." Observations in regions 5, 6, 9, and 11 are above both thresholds, and are thus predicted to be treated, assuming the student is also above the College GPA threshold. The L-shape bandwidth is given by regions 1, 2, 3, 5, 6, 7, 9, and 10 (and extends above regions 1 and 5 and to the right of regions 9 and 10). The box bandwidth is given by regions 2, 3, 6, and 7.

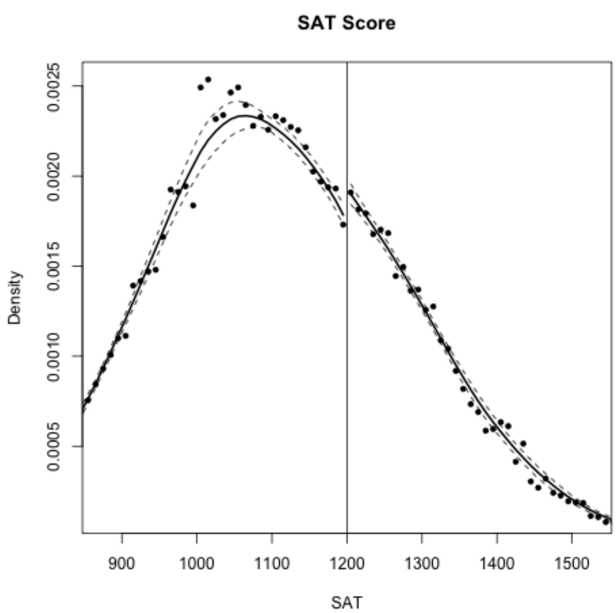
Figure 2: Tests for Manipulation of the Forcing Variables



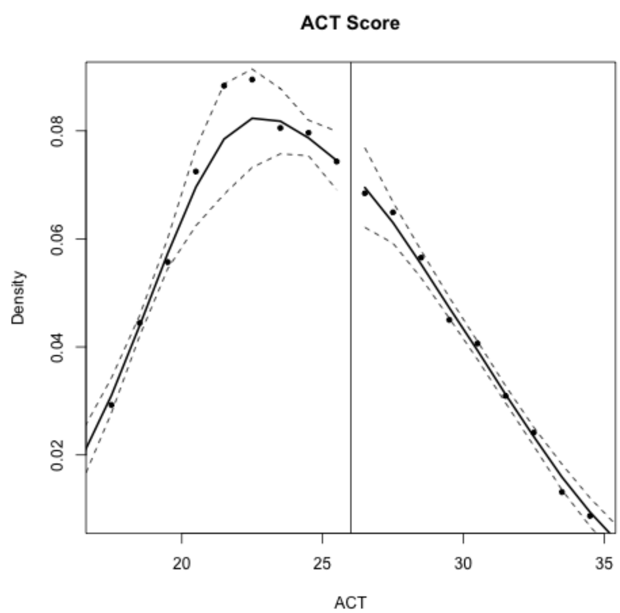

(a) High School GPA




(b) College GPA




(c) SAT




(d) ACT

Notes: These figures are McCrary checks for manipulation of the running variables. The sample is after all sample restrictions. We do not combine SAT and ACT here as the combined version is less informative. We exclude the extreme far right tail of ACT score and College GPA due to them having very few observations.

# Appendix Tables

Table A.1: Smoothness

| | (1) Male | (2) Black | (3) AGI | (4) UGA/Tech | (5) Ever Pell | (6) Credits by 20114 |
|---|---|---|---|---|---|---|
| Above Cutoffs | -0.02 | -0.00 | -0.00 | 0.00 | -0.02 | 0.04 |
| | (0.02) | (0.01) | (0.04) | (0.02) | (0.02) | (0.83) |
| Test, Below | 0.14 | -0.02 | 0.26*** | 0.73*** | -0.13** | 4.78** |
| | (0.11) | (0.04) | (0.08) | (0.09) | (0.07) | (2.00) |
| Test, Above | 0.22*** | -0.06*** | 0.30*** | 0.31*** | -0.12*** | 10.66*** |
| | (0.02) | (0.01) | (0.05) | (0.02) | (0.02) | (0.86) |
| HS GPA, Below | -0.39 | -0.05 | 0.42 | 0.46 | 0.50 | 9.69 |
| | (0.28) | (0.24) | (0.75) | (0.35) | (0.52) | (17.69) |
| HS GPA, Above | 0.06 | -0.01 | -0.29** | 0.11 | 0.09 | 7.69*** |
| | (0.08) | (0.04) | (0.14) | (0.08) | (0.08) | (2.89) |
| Test*HS GPA, Below | 2.44 | 0.80 | -0.95 | -2.14 | -0.61 | -30.16 |
| | (1.85) | (1.22) | (1.79) | (2.03) | (2.19) | (63.63) |
| Test*HS GPA, Above | 0.19 | -0.04 | 0.39 | 0.02 | -0.19 | 4.59 |
| | (0.27) | (0.13) | (0.43) | (0.27) | (0.27) | (8.84) |
| N | 6415 | 6438 | 7364 | 6027 | 6565 | 7384 |
| R2 | 0.04 | 0.01 | 0.03 | 0.14 | 0.02 | 0.06 |
| Test BW | 0.38 | 0.46 | 0.69 | 0.41 | 0.51 | 0.62 |
| HS GPA BW | 0.14 | 0.08 | 0.11 | 0.11 | 0.08 | 0.09 |
| Term | 20114 | 20114 | 20114 | 20114 | 20114 | 20114 |
| Y Mean | 0.41 | 0.06 | 1.03 | 0.61 | 0.35 | 49.56 |

Notes: This table tests for smoothness through the thresholds for the following variables: *Male*, *Black*, *AGI* (adjusted gross income), *UGA/Tech* (attended the University of Georgia or Georgia Tech in Spring 2010-11), *Ever Pell* (ever received Pell during the sample), and *Credits by 20114* (the number of credits by the end of the Spring 2010-11 semester). *AGI* is divided by $1,000. The variable of interest, *Above Cutoffs*, is an indicator for being above both thresholds. *Test, Below* and *Test, Above* are equivalent to the test score variable, except *Test, Below* is 0 where the test score is greater or equal to 0, and *Test, Above* is 0 where the test score variable is less than 0. *HS GPA, Below* and *HS GPA, Above* are analogously defined. Interactions between *Test, Below* and *HS GPA, Below*, as well as *Test, Above* and *HS GPA, Above* are also included. The L-shape bandwidth is used and is chosen as described in Section 4.1.1. The test and HS GPA bandwidths are listed at the bottom of the table, as is the mean of the dependent variables over the sample used in the corresponding regression. Sample is not restricted to those with centered college GPA above or equal to 0. Robust standard errors are used. * 0.10, ** 0.05, *** 0.01.

Table A.2: Robustness Checks - No Covariates

| | Zell | HOPE+Zell | Enrolled | Grad 4 Yr | Loans | Grants | Total Grants |
|---|---|---|---|---|---|---|---|
| *Panel A: L-Shape Bandwidth* | | | | | | | |
| College GPA≥0 | 0.74*** | 382.88*** | -0.00 | 0.01 | 78.80 | -54.53 | 330.91*** |
| | (0.02) | (45.53) | (0.01) | (0.02) | (90.19) | (79.21) | (96.33) |
| Full Sample | 0.49*** | 206.39*** | 0.01 | -0.00 | 87.56 | -187.56** | -16.27 |
| | (0.02) | (51.65) | (0.01) | (0.02) | (94.20) | (86.15) | (104.97) |
| *Panel B: Box Bandwidth* | | | | | | | |
| College GPA≥0 | 0.76*** | 316.00*** | -0.02 | -0.02 | 207.58 | -118.94 | 176.10 |
| | (0.04) | (80.03) | (0.01) | (0.04) | (146.92) | (134.17) | (177.39) |
| Full Sample | 0.48*** | 167.59 | 0.01 | -0.03 | 308.57** | -421.86*** | -333.89 |
| | (0.04) | (106.08) | (0.02) | (0.04) | (151.77) | (155.03) | (204.06) |
| *Panel C: 3D RD* | | | | | | | |
| L-Shape Bandwidth | 0.60*** | 384.94*** | -0.01 | 0.00 | 24.66 | -130.52 | 218.07 |
| | (0.03) | (61.60) | (0.01) | (0.03) | (121.75) | (104.58) | (132.85) |
| Box Bandwidth | 0.52*** | 469.21*** | -0.03 | -0.09 | 303.89 | -204.04 | 325.74 |
| | (0.11) | (147.88) | (0.02) | (0.06) | (269.69) | (227.34) | (330.05) |
| *Panel D: Exclude $0* | | | | | | | |
| L-Shape BW; Col. GPA≥0 | 0.73*** | 506.59*** | -0.01 | 0.02 | 87.06 | -57.14 | 435.32*** |
| | (0.02) | (40.33) | (0.01) | (0.02) | (91.79) | (78.58) | (95.86) |

Notes: This table shows robustness checks. Each coefficient is the *Above Cutoffs* coefficient from a different regression. Each column corresponds to a different outcome. Panel A uses the L-Shape bandwidth. The first set of coefficients restrict the sample to those with centered college GPA above 0; they are a reproduction of the *Above Cutoffs* estimates from Table 3. The second set of estimates in Panel A does not make the centered college GPA restriction. Panel B is the same as Panel A, but uses the Box bandwidth. Panel C shows results for a 3D RD, with the first set of estimates using the L-Shape bandwidth and the second set using the Box bandwidth. Panel D is the same as the first set of estimates in Panel A, but restricts individuals who were coded as receiving HOPE in Spring 2011 or HOPE (Zell) in Fall 2012, but also coded as receiving $0 of HOPE (Zell) money in that semester.

Notes: The tables on the following three pages (Tables A.3-A.9) show various specifications, with each table corresponding to a different outcome. The third column corresponds to Table A.2. In a given table, each coefficient is the *Above Cutoffs* coefficient from a different regression. Each column corresponds to a different specification, indicated by the X's below the table. *Main Effects* is *Test* and *HS GPA* for the 2D specifications and these plus *College GPA* for 3D. *A (Above) &B (Below) Main Effects* allow the main effects to vary above and below the cutoff. *A&B Main Effects Interactions* interact the main effects, separately for above and below (the 3D case also includes triple interactions, one for above and one for below). *A&B Main Effects Interactions+* , shown only for the 2D case, are the interactions of the main effects, combining above and below: College GPA Below interacted with HS GPA Above, and College GPA Above interacted with HS GPA Below. *Above Indicators* are indicators for passing the cutoff (two (three) for the 2D (3D) case). Panel A uses the L-Shape bandwidth. The first set of coefficients restrict the sample to those with centered college GPA above 0; they are a reproduction of the *Above Cutoffs* estimates from Table 3. The second set of estimates in Panel A does not make the centered college GPA restriction. Panel B is the same as Panel A, but uses the Box bandwidth. Panel C shows results for a 3D RD, with the first set of estimates using the L-Shape bandwidth and the second set using the Box bandwidth.

Table A.3: Zell Receipt, Various Specifications

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Panel A: L-Shape Bandwidth | | | | | | |
| College GPA≥0 | 0.78*** | 0.79*** | 0.74*** | 0.83*** | 0.76*** | 0.74*** |
| | (0.01) | (0.01) | (0.02) | (0.01) | (0.02) | (0.02) |
| Full Sample | 0.54*** | 0.56*** | 0.50*** | 0.60*** | 0.52*** | 0.50*** |
| | (0.01) | (0.01) | (0.02) | (0.01) | (0.02) | (0.02) |
| Panel B: Box Bandwidth | | | | | | |
| College GPA≥0 | 0.77*** | 0.78*** | 0.76*** | 0.79*** | 0.76*** | 0.77*** |
| | (0.03) | (0.03) | (0.04) | (0.03) | (0.04) | (0.04) |
| Full Sample | 0.48*** | 0.49*** | 0.49*** | 0.49*** | 0.48*** | 0.47*** |
| | (0.03) | (0.03) | (0.04) | (0.03) | (0.04) | (0.04) |
| Panel C: 3D RD | | | | | | |
| L-Shape Bandwidth | 0.70*** | 0.66*** | 0.60*** | 0.52*** | 0.51*** | |
| | (0.02) | (0.03) | (0.03) | (0.04) | (0.05) | |
| Box Bandwidth | 0.58*** | 0.57*** | 0.53*** | 0.48*** | 0.45*** | |
| | (0.07) | (0.07) | (0.11) | (0.10) | (0.14) | |
| Main Effects | X | | | | | |
| A&B Main Effects | | X | X | X | X | X |
| A&B Main Effects Interactions | | | X | | X | X |
| A&B Main Effects Interactions+ | | | | | | X |
| Above Indicators | | | | X | X | |

Table A.4: HOPE+Zell, Fall 2011-12, Various Specifications

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Panel A: L-Shape Bandwidth | | | | | | |
| College GPA≥0 | 413.60*** | 394.45*** | 334.37*** | 468.85*** | 439.83*** | 333.73*** |
| | (22.42) | (25.38) | (31.36) | (40.87) | (64.61) | (31.38) |
| Full Sample | 286.95*** | 272.12*** | 188.44*** | 355.33*** | 254.92** | 186.65*** |
| | (32.39) | (37.27) | (45.73) | (62.61) | (99.19) | (45.89) |
| Panel B: Box Bandwidth | | | | | | |
| College GPA≥0 | 334.46*** | 329.02*** | 316.26*** | 364.16*** | 376.63*** | 304.43*** |
| | (43.19) | (42.84) | (52.91) | (53.42) | (77.69) | (54.62) |
| Full Sample | 193.62*** | 191.86*** | 183.51* | 205.87** | 208.51 | 196.64** |
| | (74.04) | (74.02) | (94.63) | (87.84) | (133.56) | (95.05) |
| Panel C: 3D RD | | | | | | |
| L-Shape Bandwidth | 410.62*** | 352.19*** | 362.08*** | 287.80** | 285.94* | |
| | (29.93) | (33.20) | (43.99) | (115.24) | (161.53) | |
| Box Bandwidth | 375.18*** | 359.13*** | 409.67*** | 378.73** | 345.66 | |
| | (78.47) | (78.64) | (102.77) | (179.27) | (233.05) | |
| Main Effects | X | | | | | |
| A&B Main Effects | | X | X | X | X | X |
| A&B Main Effects Interactions | | | X | | X | X |
| A&B Main Effects Interactions+ | | | | | | X |
| Above Indicators | | | | X | X | |

Table A.5: Enrolled Fall 2011-12, Various Specifications

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Panel A: L-Shape Bandwidth | | | | | | |
| College GPA≥0 | 0.00 | -0.00 | -0.01 | -0.01 | -0.01 | -0.01 |
| | (0.01) | (0.01) | (0.01) | (0.02) | (0.03) | (0.01) |
| Full Sample | 0.00 | 0.01 | 0.01 | -0.01 | -0.02 | 0.01 |
| | (0.01) | (0.01) | (0.01) | (0.01) | (0.02) | (0.01) |
| Panel B: Box Bandwidth | | | | | | |
| College GPA≥0 | -0.01 | -0.02 | -0.02 | -0.01 | -0.02 | -0.02 |
| | (0.01) | (0.01) | (0.01) | (0.02) | (0.03) | (0.01) |
| Full Sample | 0.01 | 0.01 | 0.02 | -0.00 | -0.01 | 0.02 |
| | (0.01) | (0.01) | (0.02) | (0.02) | (0.03) | (0.02) |
| Panel C: 3D RD | | | | | | |
| L-Shape Bandwidth | -0.00 | -0.00 | -0.01 | 0.00 | 0.00 | |
| | (0.01) | (0.01) | (0.01) | (0.03) | (0.04) | |
| Box Bandwidth | -0.02 | -0.02 | -0.03 | -0.02 | 0.02 | |
| | (0.02) | (0.02) | (0.02) | (0.04) | (0.05) | |
| Main Effects | X | | | | | |
| A&B Main Effects | | X | X | X | X | X |
| A&B Main Effects Interactions | | | X | | X | X |
| A&B Main Effects Interactions+ | | | | | | X |
| Above Indicators | | | | X | X | |

Table A.6: Graduated in 4 Years, Various Specifications

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Panel A: L-Shape Bandwidth | | | | | | |
| College GPA≥0 | -0.01 | -0.01 | -0.00 | -0.02 | -0.00 | 0.00 |
| | (0.02) | (0.02) | (0.02) | (0.03) | (0.05) | (0.02) |
| Full Sample | 0.00 | -0.01 | -0.01 | -0.02 | -0.01 | -0.00 |
| | (0.01) | (0.02) | (0.02) | (0.03) | (0.04) | (0.02) |
| Panel B: Box Bandwidth | | | | | | |
| College GPA≥0 | -0.01 | -0.01 | -0.04 | 0.01 | -0.03 | -0.04 |
| | (0.03) | (0.03) | (0.04) | (0.04) | (0.06) | (0.04) |
| Full Sample | -0.01 | -0.02 | -0.03 | -0.01 | -0.03 | -0.03 |
| | (0.03) | (0.03) | (0.04) | (0.03) | (0.05) | (0.04) |
| Panel C: 3D RD | | | | | | |
| L-Shape Bandwidth | 0.01 | -0.01 | -0.01 | -0.03 | -0.02 | |
| | (0.02) | (0.02) | (0.03) | (0.07) | (0.09) | |
| Box Bandwidth | -0.02 | -0.02 | -0.07 | -0.05 | -0.04 | |
| | (0.04) | (0.04) | (0.06) | (0.10) | (0.13) | |
| Main Effects | X | | | | | |
| A&B Main Effects | | X | X | X | X | X |
| A&B Main Effects Interactions | | | X | | X | X |
| A&B Main Effects Interactions+ | | | | | | X |
| Above Indicators | | | | X | X | |

Table A.7: Loans, Fall 2011-12, Various Specifications

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Panel A: L-Shape Bandwidth | | | | | | |
| College GPA≥0 | 71.28 | 89.30 | 60.30 | 193.28* | 231.29 | 58.94 |
| | (64.32) | (72.05) | (88.72) | (114.76) | (172.25) | (88.81) |
| Full Sample | 95.85 | 104.38 | 76.24 | 156.49 | 114.59 | 73.67 |
| | (65.06) | (75.33) | (92.90) | (109.91) | (168.45) | (92.99) |
| Panel B: Box Bandwidth | | | | | | |
| College GPA≥0 | 128.36 | 127.71 | 147.44 | 187.18 | 298.89 | 149.00 |
| | (117.58) | (118.10) | (144.06) | (148.24) | (209.85) | (147.73) |
| Full Sample | 215.83* | 228.42* | 309.83** | 189.24 | 310.73 | 337.75** |
| | (119.66) | (119.63) | (149.62) | (148.22) | (213.19) | (153.78) |
| Panel C: 3D RD | | | | | | |
| L-Shape Bandwidth | -74.32 | 52.13 | 16.13 | 361.64 | 161.55 | |
| | (84.50) | (92.47) | (118.91) | (314.10) | (438.10) | |
| Box Bandwidth | 161.54 | 184.95 | 255.73 | 322.96 | 505.67 | |
| | (203.14) | (202.70) | (264.80) | (470.42) | (595.05) | |
| Main Effects | X | | | | | |
| A&B Main Effects | | X | X | X | X | X |
| A&B Main Effects Interactions | | | X | | X | X |
| A&B Main Effects Interactions+ | | | | | | X |
| Above Indicators | | | | X | X | |

Table A.8: Grants, Fall 2011-12, Various Specifications

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Panel A: L-Shape Bandwidth | | | | | | |
| College GPA≥0 | -21.59 | -28.98 | -47.69 | -22.38 | -47.48 | -47.13 |
| | (37.81) | (47.86) | (61.50) | (72.16) | (115.95) | (61.54) |
| Full Sample | -24.62 | -48.12 | -110.47* | -39.18 | -202.45 | -109.48* |
| | (36.09) | (53.22) | (65.89) | (85.28) | (134.65) | (66.03) |
| Panel B: Box Bandwidth | | | | | | |
| College GPA≥0 | -122.17 | -97.42 | -60.47 | -96.94 | -19.70 | -93.45 |
| | (80.99) | (82.60) | (106.72) | (102.43) | (149.03) | (108.03) |
| Full Sample | -152.56* | -139.01 | -263.14** | -120.30 | -368.74** | -291.34** |
| | (84.88) | (89.20) | (116.64) | (118.53) | (177.69) | (117.19) |
| Panel C: 3D RD | | | | | | |
| L-Shape Bandwidth | 3.59 | 50.89 | -66.13 | 207.08 | -47.84 | |
| | (53.21) | (62.76) | (80.07) | (215.82) | (296.48) | |
| Box Bandwidth | -85.64 | -108.90 | -329.33* | 422.36 | 105.21 | |
| | (123.02) | (124.16) | (174.41) | (312.86) | (408.33) | |
| Main Effects | X | | | | | |
| A&B Main Effects | | X | X | X | X | X |
| A&B Main Effects Interactions | | | X | | X | X |
| A&B Main Effects Interactions+ | | | | | | X |
| Above Indicators | | | | X | X | |

Table A.9: Total Grants, Fall 2011-12, Various Specifications

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Panel A: L-Shape Bandwidth | | | | | | |
| College GPA≥0 | 383.03*** | 375.33*** | 301.86*** | 459.09*** | 440.96*** | 304.08*** |
| | (46.38) | (57.39) | (72.69) | (92.87) | (151.81) | (72.76) |
| Full Sample | 230.44*** | 173.59** | 70.62 | 270.10** | 186.39 | 75.62 |
| | (50.74) | (71.09) | (86.65) | (123.68) | (194.19) | (86.52) |
| Panel B: Box Bandwidth | | | | | | |
| College GPA≥0 | 170.33 | 198.87* | 246.41* | 238.81* | 382.83** | 201.89 |
| | (105.28) | (107.85) | (136.16) | (132.54) | (194.47) | (138.17) |
| Full Sample | 59.23 | 62.81 | -137.00 | 207.59 | -61.58 | -205.24 |
| | (125.97) | (131.87) | (164.18) | (171.67) | (256.74) | (166.74) |
| Panel C: 3D RD | | | | | | |
| L-Shape Bandwidth | 416.52*** | 444.24*** | 252.65** | 376.91 | 184.34 | |
| | (71.14) | (84.24) | (105.66) | (283.12) | (404.53) | |
| Box Bandwidth | 159.24 | 135.04 | 25.19 | 220.29 | 285.82 | |
| | (184.55) | (185.89) | (246.26) | (429.55) | (545.73) | |
| Main Effects | X | | | | | |
| A&B Main Effects | | X | X | X | X | X |
| A&B Main Effects Interactions | | | X | | X | X |
| A&B Main Effects Interactions+ | | | | | | X |
| Above Indicators | | | | X | X | |

Table A.10: Locations Approach, Not Conditional on College GPA

| | (1) Zell | (2) HOPE+Zell | (3) Enrolled | (4) Grad 4 Yr | (5) Loans | (6) Grants | (7) Total Grants |
|---|---|---|---|---|---|---|---|
| Cutoff 1 - (0; .15) | 0.39*** | 67.36 | 0.01 | -0.03 | 30.96 | -258.87** | -243.72 |
| | (0.04) | (78.97) | (0.01) | (0.03) | (136.28) | (116.85) | (153.74) |
| Cutoff 2 - (0; 0) | 0.41*** | 107.96 | 0.02 | -0.00 | 248.23 | -306.29** | -85.48 |
| | (0.04) | (96.20) | (0.01) | (0.04) | (187.58) | (135.43) | (173.42) |
| Cutoff 3 - (1; 0) | 0.51*** | 305.72 | -0.01 | -0.12 | -282.38 | 143.19 | 419.52 |
| | (0.11) | (226.31) | (0.01) | (0.08) | (379.36) | (279.29) | (357.25) |
| Cutoff 1 BW | 0.30 | 0.65 | 0.78 | 0.74 | 0.85 | 0.56 | 0.50 |
| Cutoff 2 BW | 0.41 | 0.66 | 0.81 | 0.71 | 0.63 | 0.39 | 0.45 |
| Cutoff 3 BW | 0.20 | 0.37 | 0.28 | 0.44 | 0.37 | 0.31 | 0.36 |
| Cutoff 1 N | 1597 | 6729 | 10447 | 9668 | 11556 | 5476 | 4241 |
| Cutoff 2 N | 4035 | 8129 | 12625 | 10780 | 8475 | 3706 | 4526 |
| Cutoff 3 N | 298 | 903 | 572 | 1346 | 937 | 716 | 899 |
| Term | 20122 | 20122 | 20114 | 20114 | 20122 | 20122 | 20122 |

Notes: This table, which uses the locations approach described in Section 6, has the following dependent variables: *Zell* (received Zell in Fall 2012), *Hope+Zell* (the combined amount of HOPE and Zell received in Fall 2012), *Enrolled* (enrolled in Fall 2012), *Grad 4 Yr* (graduated in 4 years), *Loans* (amount of loans received in Fall 2012), *Grants* (the amount of grants received in Fall 2012, excluding HOPE and Zell), and *Total Grants*, the sum of Hope+Zell money and grants. Each coefficient is an estimate for a different part of the joint distribution of test score and HS GPA. *(0; 0.15)* refers to a test score of 0 and a HS GPA of 0.15, both of which are centered. The sample is unconditional. * 0.10, ** 0.05, *** 0.01.

Table A.11: L-Shape, 2D, Outcomes, Separate by Cohort

| | (1) Zell | (2) Zell | (3) Hope+Zell | (4) Hope+Zell | (5) Enrolled | (6) Enrolled | (7) Grad 4 Yr | (8) Grad 4 Yr |
|---|---|---|---|---|---|---|---|---|
| Above Cutoffs | 0.77*** | 0.74*** | 403.55*** | 278.49*** | -0.02 | 0.00 | -0.00 | -0.01 |
| | (0.02) | (0.02) | (45.19) | (40.99) | (0.01) | (0.01) | (0.03) | (0.03) |
| Test, Below | 0.05 | -0.04 | -113.09 | 110.38 | 0.03 | -0.03 | 0.04 | 0.03 |
| | (0.05) | (0.06) | (118.45) | (98.19) | (0.04) | (0.03) | (0.06) | (0.05) |
| Test, Above | 0.01 | 0.04* | -111.19** | -41.56 | -0.01 | 0.00 | -0.05 | -0.11*** |
| | (0.02) | (0.02) | (45.51) | (37.30) | (0.01) | (0.01) | (0.03) | (0.03) |
| HS GPA, Below | 1.06*** | 1.21*** | 2078.03** | 1199.62** | 0.37 | 0.05 | 0.09 | -0.68 |
| | (0.23) | (0.32) | (839.07) | (477.82) | (0.41) | (0.30) | (0.40) | (0.68) |
| HS GPA, Above | 0.05 | 0.22*** | -706.13*** | -470.49*** | -0.03 | 0.00 | 0.28** | 0.15 |
| | (0.08) | (0.08) | (169.78) | (157.81) | (0.05) | (0.04) | (0.11) | (0.11) |
| Test*HS GPA, Below | 1.91** | 2.22** | -1119.64 | 3289.95* | 0.67 | 0.90 | 0.96 | -1.47 |
| | (0.78) | (1.06) | (3134.35) | (1752.51) | (2.23) | (0.95) | (1.06) | (1.74) |
| Test*HS GPA, Above | 0.92*** | 0.95*** | 1110.73** | 1568.63*** | 0.17 | 0.05 | -0.17 | -0.04 |
| | (0.25) | (0.25) | (505.65) | (435.85) | (0.12) | (0.14) | (0.27) | (0.24) |
| Cohort | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 |
| N | 2251 | 2323 | 2253 | 2739 | 2060 | 2295 | 3079 | 3336 |
| R2 | 0.76 | 0.71 | 0.60 | 0.64 | 0.03 | 0.01 | 0.20 | 0.14 |
| Test BW | 0.54 | 0.51 | 0.63 | 0.61 | 0.60 | 0.52 | 0.78 | 0.84 |
| HS GPA BW | 0.11 | 0.08 | 0.09 | 0.14 | 0.05 | 0.08 | 0.13 | 0.09 |
| Term | 20122 | 20122 | 20122 | 20122 | 20114 | 20114 | 20114 | 20114 |
| Y Mean | 0.44 | 0.46 | 2781.96 | 2633.11 | 0.98 | 0.98 | 0.58 | 0.54 |
| Covariates | x | x | x | x | x | x | x | x |

Notes: This table shows the main table split by the 2009 and 2010 cohorts. It is conditional on the centered college GPA being above 0. It uses the L-shape bandwidth and the functional form of equation 2 in the text, and has the following dependent variables: *Zell* (received Zell in Fall 2012), *Hope+Zell* (the combined amount of HOPE and Zell received in Fall 2012), *Enrolled* (enrolled in Fall 2012), and *Grad 4 Yr* (graduated in 4 years). The odd- (even-) numbered columns are for the 2009 (2010) cohorts. The variable of interest, *Above Cutoffs*, is an indicator for being above both thresholds. *Test, Below* and *Test, Above* are equivalent to the test score variable, except *Test, Below* is 0 where the test score is greater or equal to 0, and *Test, Above* is 0 where the test score variable is less than 0. *HS GPA, Below* and *HS GPA, Above* are analogously defined. Interactions between *Test, Below* and *HS GPA, Below*, as well as *Test, Above* and *HS GPA, Above* are also included. The L-shape bandwidth is used and is chosen as described in Section 4.1.1. The test and HS GPA bandwidths are listed at the bottom of the table, as is the mean of the dependent variables over the sample used in the corresponding regression. Covariates are included, and robust standard errors are used. * 0.10, ** 0.05, *** 0.01.

Table A.12: L-Shape, 2D, Money, Separate by Cohort

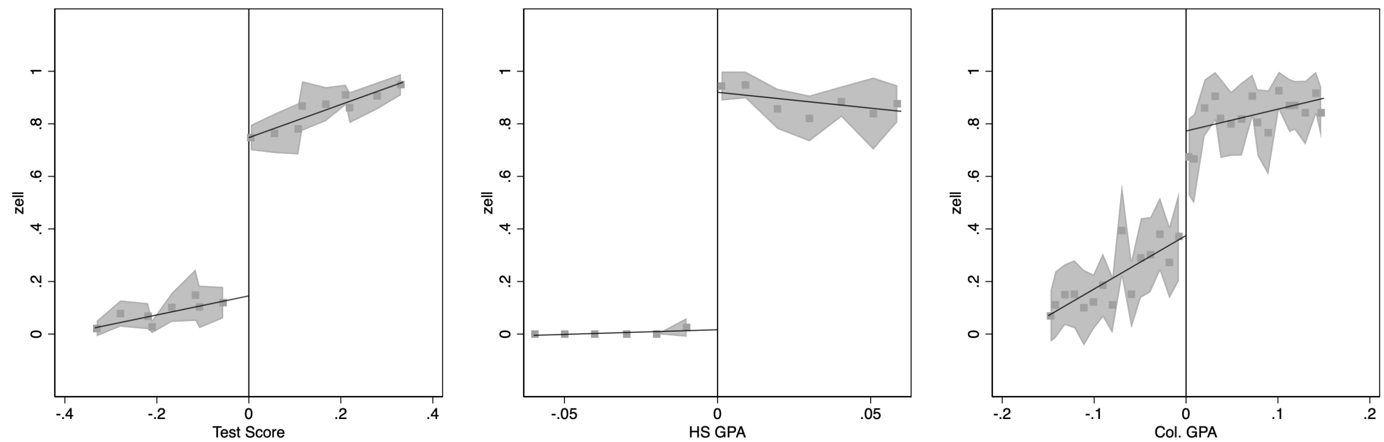
| | (1) Loans | (2) Loans | (3) Grants | (4) Grants | (5) Total Grants | (6) Total Grants |
|---|---|---|---|---|---|---|
| Above Cutoffs | 106.31 | 12.20 | 9.74 | -60.47 | 387.61*** | 222.02** |
| | (129.44) | (113.35) | (82.61) | (88.27) | (95.99) | (101.20) |
| Test, Below | -364.59 | -67.13 | 158.72 | -17.38 | 199.52 | -100.46 |
| | (276.89) | (197.67) | (242.06) | (260.49) | (278.26) | (293.79) |
| Test, Above | -493.45*** | -240.45* | 139.19* | 35.42 | -13.58 | 3.75 |
| | (135.19) | (127.67) | (80.55) | (74.83) | (95.47) | (88.63) |
| HS GPA, Below | -2469.83 | -704.80 | 501.87 | -855.71 | 3214.69*** | 518.22 |
| | (1858.60) | (1743.46) | (1009.52) | (1781.41) | (1212.06) | (1945.05) |
| HS GPA, Above | -52.14 | -756.06* | 912.11*** | 325.93 | 53.82 | -154.65 |
| | (467.65) | (395.55) | (310.28) | (271.36) | (368.45) | (327.92) |
| Test*HS GPA, Below | 1449.10 | 3291.67 | 2935.74 | -9553.27 | 8602.45* | -11504.75 |
| | (5617.79) | (4067.15) | (3778.21) | (6043.52) | (4992.12) | (7444.26) |
| Test*HS GPA, Above | 1551.35 | -15.59 | -854.25 | 1338.96 | 637.89 | 3208.53*** |
| | (1207.09) | (886.06) | (874.49) | (973.28) | (1078.70) | (1166.19) |
| Cohort | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 |
| N | 2848 | 3565 | 2467 | 2514 | 2270 | 2359 |
| R2 | 0.04 | 0.04 | 0.39 | 0.38 | 0.41 | 0.43 |
| Test BW | 0.67 | 0.88 | 0.53 | 0.60 | 0.53 | 0.56 |
| HS GPA BW | 0.12 | 0.13 | 0.13 | 0.10 | 0.13 | 0.10 |
| Term | 20122 | 20122 | 20122 | 20122 | 20122 | 20122 |
| Y Mean | 1189.27 | 1047.29 | 780.66 | 797.71 | 3573.19 | 3417.11 |
| Covariates | x | x | x | x | x | x |

Notes: This table shows the main table split by the 2009 and 2010 cohorts. It is conditional on the centered college GPA being above 0. It uses the L-shape bandwidth and the functional form of equation 2 in the text, and has the following dependent variables: *Loans* (amount of loans received in Fall 2012) *Grants* (the amount of grants received in Fall 2012, excluding HOPE and Zell), and *Total Grants*, the sum of Hope+Zell money and grants. The odd- (even-) numbered columns are for the 2009 (2010) cohorts. The variable of interest, *Above Cutoffs*, is an indicator for being above both thresholds. *Test, Below* and *Test, Above* are equivalent to the test score variable, except *Test, Below* is 0 where the test score is greater or equal to 0, and *Test, Above* is 0 where the test score variable is less than 0. *HS GPA, Below* and *HS GPA, Above* are analogously defined. Interactions between *Test, Below* and *HS GPA, Below*, as well as *Test, Above* and *HS GPA, Above* are also included. The L-shape bandwidth is used and is chosen as described in Section 4.1.1. The test and HS GPA bandwidths are listed at the bottom of the table, as is the mean of the dependent variables over the sample used in the corresponding regression. Covariates are included, and robust standard errors are used. * 0.10, ** 0.05, *** 0.01.

# Appendix Figures

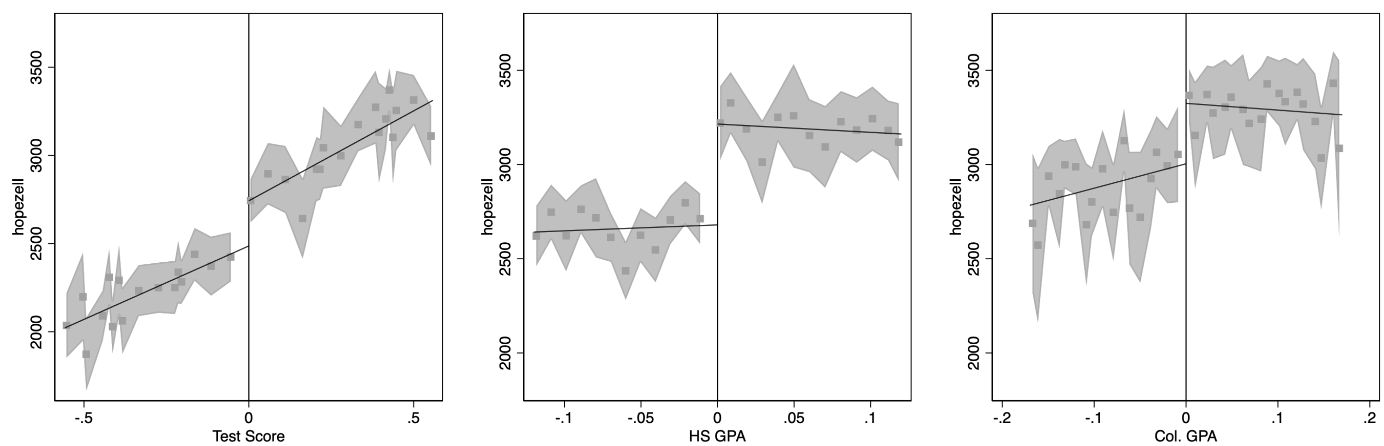
Figure A.1: Conditional 3D Plots, A

**Zell**



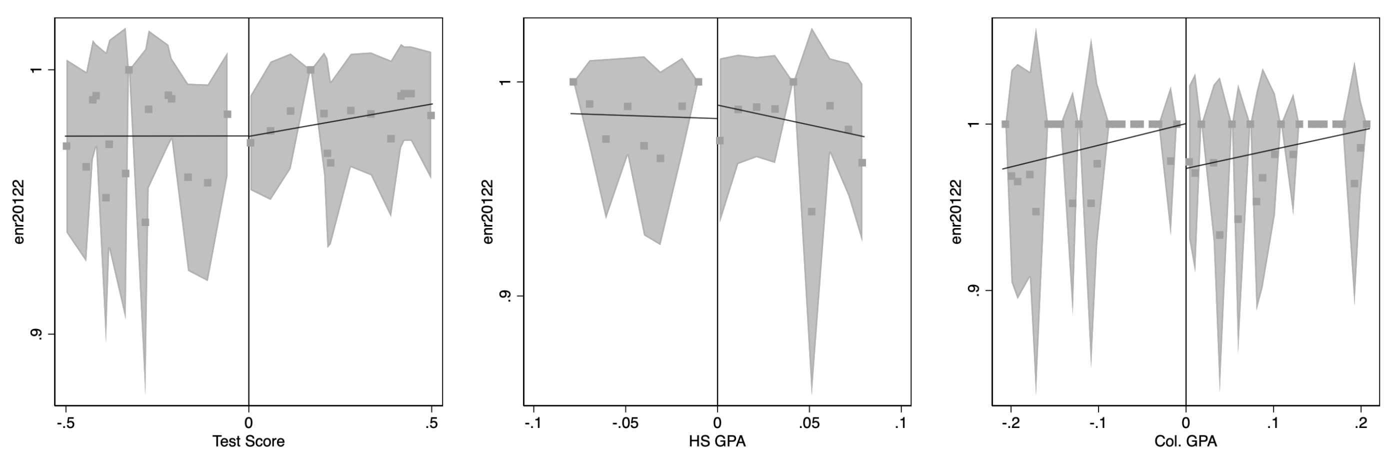

(a) Test, HS GPA≥0, Col. GPA≥0 (b) HS GPA, Test≥0, Col. GPA≥0 (c) Col. GPA, Test≥0, HS GPA≥0

**HOPE+Zell $**




(d) Test, HS GPA≥0, Col. GPA≥0 (e) HS GPA, Test≥0, Col. GPA≥0 (f) Col. GPA, Test≥0, HS GPA≥0

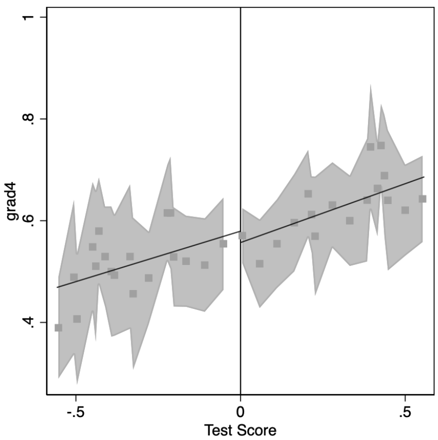
**Enrolled**



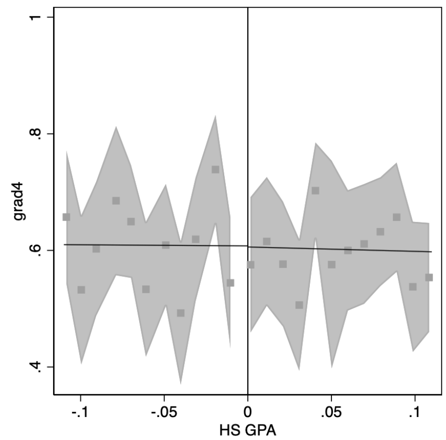

(g) Test, HS GPA≥0, Col. GPA≥0 (h) HS GPA, Test≥0, Col. GPA≥0 (i) Col. GPA, Test≥0, HS GPA≥0

Figure A.2: Conditional 3D Plots, B

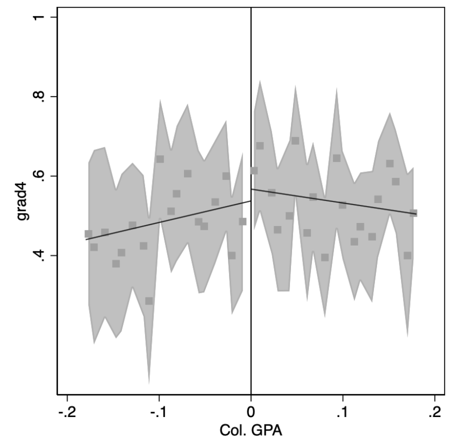
**Graduated in 4 Years**




(a) Test, HS GPA≥0, Col. GPA≥0

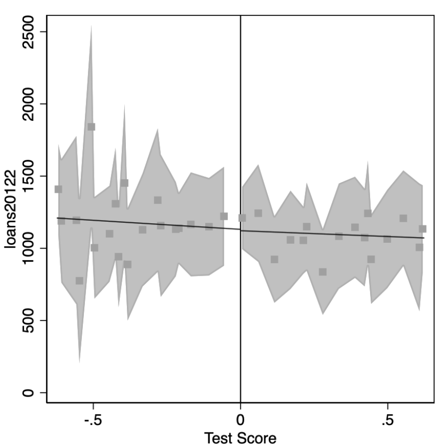



(b) HS GPA, Test≥0, Col. GPA≥0

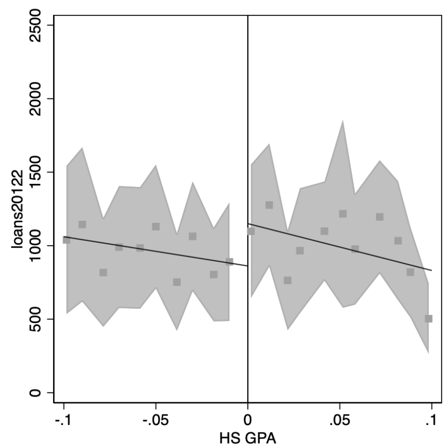



(c) Col. GPA, Test≥0, HS GPA≥0

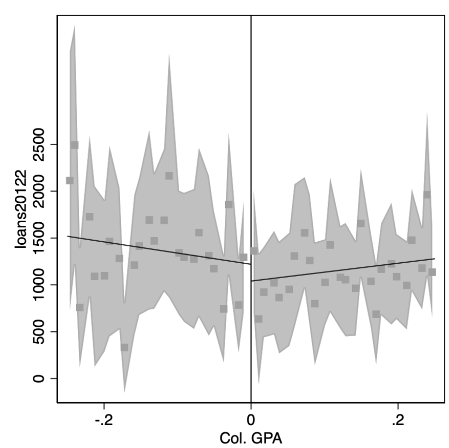
**Loans**




(d) Test, HS GPA≥0, Col. GPA≥0

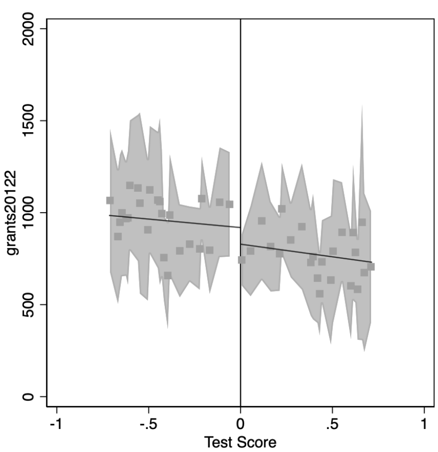



(e) HS GPA, Test≥0, Col. GPA≥0

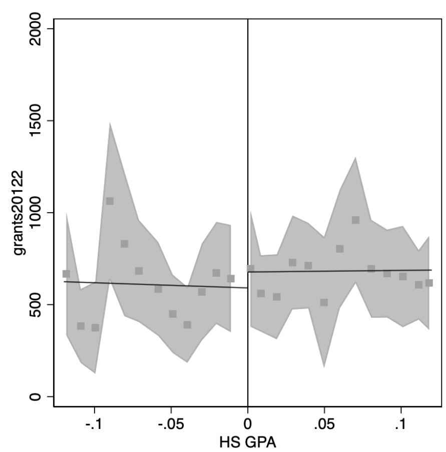



(f) Col. GPA, Test≥0, HS GPA≥0

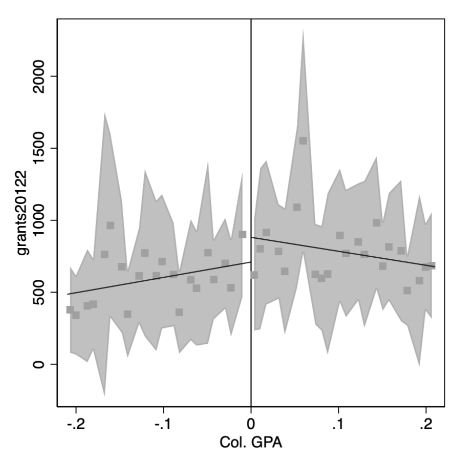
**Grants**




(g) Test, HS GPA≥0, Col. GPA≥0



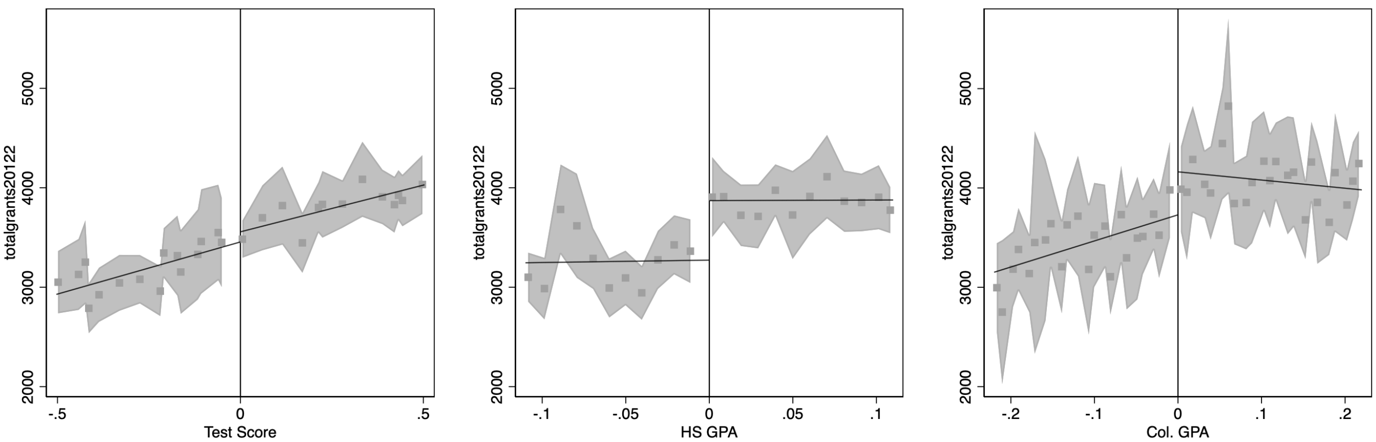

(h) HS GPA, Test≥0, Col. GPA≥0




(i) Col. GPA, Test≥0, HS GPA≥0

Figure A.3: Conditional 3D Plots, C

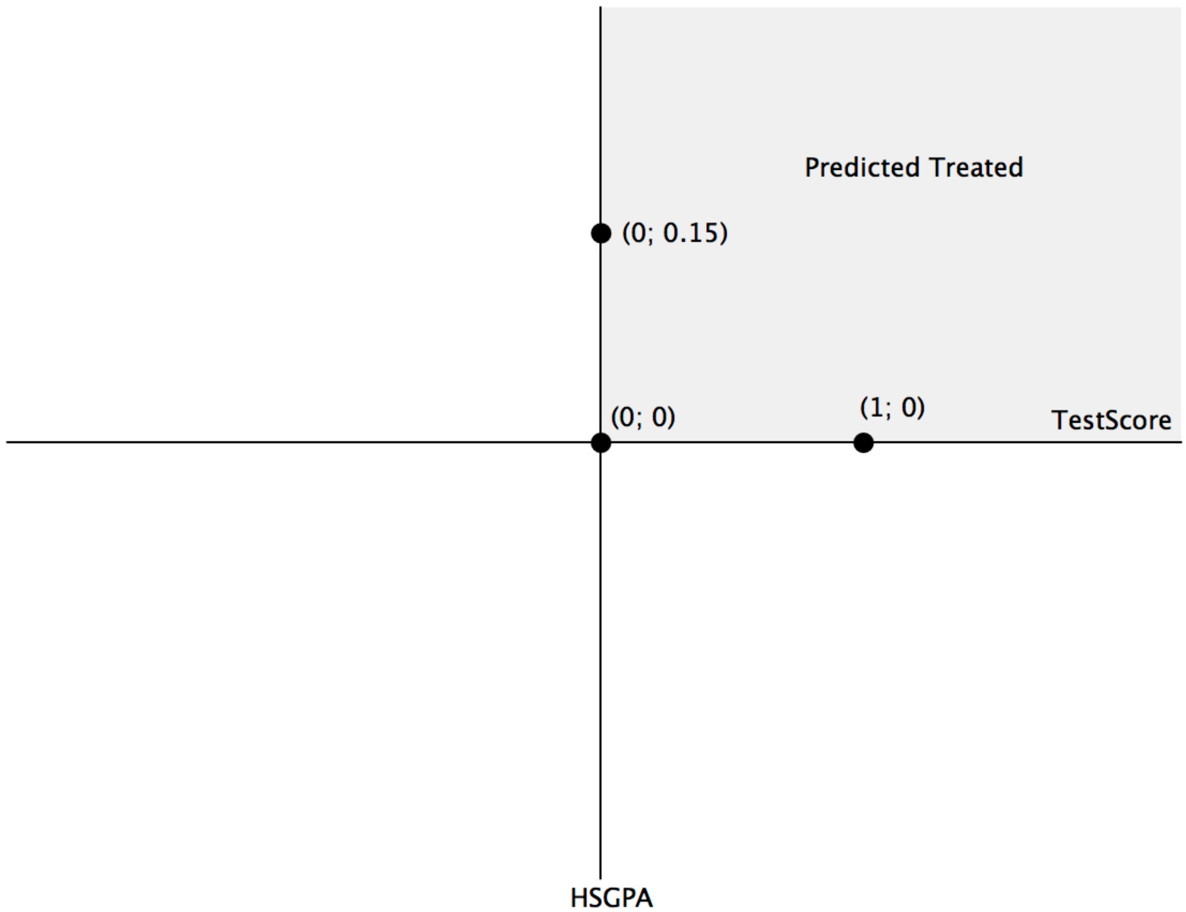
**Total Grants**




(a) Test, HS GPA≥0, Col. GPA≥0 (b) HS GPA, Test≥0, Col. GPA≥0 (c) Col. GPA, Test≥0, HS GPA≥0

Notes: The figures on this and the preceding two pages are the three-dimensional conditional plots that illustrate the effect of being over one cutoff conditional on being above the other two thresholds. Each set of three figures corresponds to a different outcome: Zell receipt, the amount of HOPE and Zell received, Enrolled, Graduated in 4 Years, Loans, Grants, and Total Grants. The figures in the left column display the average value of the outcome variable on the y-axis graphed against the x-axis, which is test score; the sample is conditional on being above the centered HS GPA and College GPA cutoffs. The figures in the center column show HS GPA on the x-axis; the sample is conditional on being above the centered test and college GPA cutoffs. The figures in the right column show college GPA on the x-axis; the sample is conditional on being above the centered test and HS GPA cutoffs. Only observations within the bandwidth produced by the rdbwselect Stata function from the rdrobust package are included. No covariates are used. 95 percent confidence intervals are shown with the shaded regions. The y-axis does not always start at 0.

Figure A.4: Locations Approach Illustration




Notes: This figure illustrates the locations approach. The x-axis and y-axis are the test score and HS GPA. HS GPA is centered at the threshold and not standardized, while test score is both. The observations in the shaded, northeast quadrant are above both thresholds, and are thus predicted to be treated. The estimates we obtain are for three points in the joint-distribution: A) (0; 0.15), where 0 is a test score of 0, and 0.15 is a HS GPA of 0.15; B) (0; 0); and C) (1; 0).