Born Under a Lucky Star: Financial Aid, College Completion, Labor Supply, and Credit Constraints

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Abstract

Financial aid can affect both college enrollment and graduation. The effects on graduation can be driven either by students induced to enroll by financial aid, students who would have enrolled anyway but graduate as a result of the financial aid, or both. This paper isolates the effect of financial aid on the second group by examining a change in aid that did not change enrollment. I study a discontinuous change in the amount of aid available to students who meet the age cutoff for financial independence I find that additional aid causes some university seniors to graduate one year earlier.

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The online appendix can be found at http://jhr.uwpress.org/

I. Introduction

Students who complete college have substantially higher wages than those who do not (Oreopoulos and Petronijevic 2013; Ost, Pan, and Webber Forthcoming). In spite of large economic returns, many students fail to complete college due to tuition costs. Financial aid, therefore, has the potential to increase college completion by reducing the tuition students pay for college.

Financial aid may increase college completion along two enrollment margins. First, financial aid may induce new students to enroll in college, some of whom go on to complete college. This channel increases college completion by increasing initial enrollment. I will call this channel the *extensive margin of college enrollment* and will refer to these students as *marginal students*. Second, financial aid may increase the graduation rate among students whose initial enrollments were not affected by financial aid. Students along this margin would enroll but ultimately fail to complete college absent the financial aid. I will call this channel the *intensive margin of college enrollment* and will refer to these students as *inframarginal students*.[1]

Most studies that consider the effect of financial aid on graduation estimate the combined intensive and extensive margin effects of financial aid on completion (Dynarski 2003; Scott-Clayton 2011; Cohodes and Goodman 2014; Castleman and Long 2016). For example, Castleman and Long (2016) examine a Florida need-based grant. They show that grant eligibility increased the probability of graduation within 7 years by 5.2 percentage points. However, they also show evidence that initial enrollment changed. Hence, the 5.2 percentage point increase in graduation represents a combination of the effects of aid eligibility on marginal and inframarginal students.

And yet this distinction between extensive and intensive margins is important for policy. In the extreme, the estimated graduation gains from financial aid could come entirely from inframarginal students while students induced to enroll all fail to graduate. Hence, the benefits to inframarginal students must be weighed against potential costs to marginal students who enroll but do not graduate. Further, understanding the effect of financial aid on the intensive margin is important for policies targeting college completion.

This paper provides evidence of the effect of an increase in financial aid for students on the intensive margin by considering already-enrolled students. For these students, I show that enrollment was not affected by financial aid. Since these students' enrollment decisions were unchanged, I can estimate the effect of financial aid for inframarginal students.

I examine additional financial aid for students who are declared financially independent from their parents. Students typically must report their parents' income and assets to determine eligibility for need-based financial aid. However, if students are declared financially independent, their parents' income and assets are not included in the eligibility calculation, which increases the students' aid eligibility. All students who are 24 years old before January 1 are considered financially independent for the entire school year, whereas students who turn 24 on or after January 1 are typically classified as dependent.[2] Thus, a student who turns 24 on December 31 will receive more financial aid than a student born on January 1. This age cutoff increases grants and loans by approximately $900 and $500, respectively. I use a regression discontinuity design to compare students just declared independent to students who just missed the age cutoff. I combine this policy variation with administrative enrollment, financial aid, and graduation records from all public universities in Texas linked to administrative earnings records.

I find that additional financial aid of approximately $1,450 induces a 1.8 percentage point increase in the probability that college seniors graduate a year earlier. I also find that the additional aid induces some sophomores and juniors to continue college rather than drop out. The acceleration in graduation seems to work by giving students the money and time to enroll in more courses. Students who receive more aid take heavier course loads without lowering their GPA and are less likely to face binding credit constraints. I also present suggestive evidence that additional aid causes students to work less.

The results are robust to varying the bandwidth used to estimate the discontinuity and excluding students born three days before or after January 1. Changes in credits attempted and other academic outcomes do not vary at the same cutoff for students who turn 21, 22, or 23, where there is no change in financial aid.

The findings of this paper can inform financial aid policy as well as decisions about the definition of financial independence. Financial aid decreases time to graduation. Since most postsecondary institutions are publicly subsidized, reducing time-to-degree represents potential cost savings for taxpayers and should be accounted for in estimating the fiscal cost of increased financial aid. Also, the additional financial aid arising from financial independence is poorly targeted. The largest increases in aid go to the students with wealthier parents. However, wealthier students' graduation is least affected by the aid. This result suggests that targeting resources to poorer students would improve graduation rates at no cost.[3] Further, this study complements the existing literature by demonstrating that some graduation gains from financial aid come from inframarginal students, which highlights the need to consider the effects of financial aid for both marginal and inframarginal students.

This paper lies at the intersection of three trends in higher education in the United States. The first is a substantial increase in the price students pay for college, making tuition costs an increasingly imposing barrier to graduation.[4] Second, while college enrollment rates have grown since 1970, college completion rates have declined and time-to-degree has increased (Bound, Lovenheim, and Turner 2010, 2012). Third, student employment has increased over this same time frame.[5] While these trends would appear to be related, there is a paucity of evidence that causally ties them together. The results from this paper suggest that some of the growth in time-to-degree and student labor supply is likely a result of tuition increases.

The rest of the paper will proceed as follows: Section II will describe the relevant literature. Section III will discuss the institutional details of financial independence. Section IV will introduce the data used, and Section V will discuss how the effect of financial aid on already-enrolled students is identified. Section VI will present the results of estimation, and Section VII will conclude.

II. Literature Review

Several papers measure the combined extensive and intensive margin effects of financial aid on graduation.[6] However, the effect of financial aid for inframarginal students has received far less attention. There are a few notable exceptions. Goldrick-Rab et al. (2016) examine the effect of privately financed aid for freshman in Wisconsin and find that additional financial aid increased persistence and graduation within four years.[7] Barr (Forthcoming) studies veteran students enrolled at the time of the expansion of education benefits for veterans and finds increased persistence. Murphy and Wyness (2016) consider financial aid in the United Kingdom that did not affect initial enrollment and find that additional financial aid increases the chances of earning a "good" degree.[8] Relative to these studies, the current paper has several advantages. This paper

considers the effect of financial aid on inframarginal students in the U.S. federal financial aid system. I study the primary source of financial aid for students in the United States whereas the other studies mentioned consider privately financed aid, aid only available to veterans, or aid in the United Kingdom. Further, I use administrative data with detailed records on grant receipt, loan take-up, credits attempted, GPA, graduation, and earnings.[9]

This paper focuses on older students. The change in financial aid studied in this paper affects older students, who are sometimes called "nontraditional" students. However, these students are more common than this label might suggest. In 2011–2012, 51.3 percent of all undergraduate students were classified as financially independent and 43.8 percent were 24 years of age or older (U.S. Department of Education 2013a). Financially independent students feature prominently among federal aid recipients and made up nearly 60 percent of Pell Grant recipients in 2010–2011 (U.S. Department of Education 2013b).[10] Older students represent an increasing share of college students. In 1970, students 25 and older constituted 27.7 percent of all undergraduate enrollment, and by 2010 they accounted for 42.6 percent (National Center for Education Statistics 2013).

Despite their growing prominence in enrollment and financial aid receipt, the response of older students to financial aid has rarely been studied. Notably, the effect of financial independence on educational outcomes has previously been studied by Seftor and Turner (2002). These researchers use the Current Population Survey (CPS) and find that the additional financial aid arising from financial independence increases student enrollment. Seftor and Turner (2002) use a differences-in-differences framework to examine the impact of a 1986 policy change that changed the age at which students were classified as independent. They use a single policy change, which requires assumptions that outcomes would have followed parallel trends and no

other contemporaneous shock was experienced. The differences-in-differences estimator used by Seftor and Turner (2002) compares students across cohorts within age bins.[11] My research uses a regression discontinuity that performs a different comparison. Namely, I use students born just after January 1 as a counterfactual for students born just before. This approach allows a comparison of very similar students within cohort and school and generates tests of the identifying assumptions. Also, Seftor and Turner (2002) cannot estimate the effects of aid on student performance or graduation due to the limitations of the CPS. The current paper builds on Seftor and Turner (2002) by using student-level administrative data for recent cohorts and considers new outcomes including GPA, credits attempted, graduation, and earnings.[12] I also document the heterogeneous effects of financial aid by family resources.

III. Background

The U.S. federal government has several financial programs that are designed to help students pay for college. A host of factors determine students' eligibility for these programs, including income, assets, and family structure. A primary consideration is whether parent's income and assets are considered—that is, whether students are financially independent. The distinction between dependent and independent students does not need to reflect actual financial dependence; rather, this distinction deals with statutes governing the amount of financial aid disbursed. There are two broad categories of federal aid that are affected by financial independence. The first set of programs is administered by the U.S. Department of Education, which I will refer to as "federal financial aid." The second set of programs is a part of the U.S. tax code, which I will refer to as "tax aid." I discuss this second category in Appendix A.1.

Federal financial aid consists of federal grants, student loans, and work-study. In order to be eligible for federal need-based financial aid, students must file a Free Application for Federal

Student Aid (FAFSA). The FAFSA asks for information about income, assets, and demographics that is then fed into a complex formula to compute eligibility for federal need-based financial aid programs. In general, federal financial aid awards are calculated yearly.[13]

If students are considered financially dependent, they must include their parents' information on their FAFSA. Undergraduate students may be classified as financially independent for several reasons, including being over 24 years old before January 1, being married, having dependent children, or a few other reasons.[14] All else being equal, independent students generally qualify for larger amounts of need-based financial aid (both grants and subsidized loans) than dependent students. Independent students are eligible for higher annual (and aggregate) federal loan limits.

Independent status based on age is determined once a year. Students who turn 24 years old before January 1 will be independent for the entire school year. Students turning 24 on or after January 1 who meet the other conditions for dependent status will be declared dependent for the entire year. This rule leads to students who are very similar in age (and other characteristics) having different eligibility for financial aid. This institutional oddity will be leveraged to examine the effect of additional financial aid arising from financial independence.

IV. Data

The primary data for this project come from the Texas Higher Education Coordinating Board (THECB) and contain the universe of students who were enrolled in public universities in the state of Texas from 2002–2003 to 2013–2014. The data contain student demographic information including race, gender, and birth date. They also contain records on student enrollment, credits attempted, and graduation. Importantly, the data include information on financial aid disbursed by the university.[15] Some fields from the FAFSA are available, including

Expected Family Contribution (EFC). Data from the Texas Workforce Commission's (TWC) Unemployment Insurance system are linked to individual student records and contain quarterly earnings.[16]

Student outcome variables will be defined by academic year. For instance, graduation in the "current year" means graduation in the year that a student turns 24. Graduation by the "next year" means graduation by the next academic year (the year a student turns 25). Quarterly earnings are aggregated into yearly earnings and correspond to the school year. To be explicit, yearly earnings are defined as quarter 4 in year $t-1$ and quarters 1, 2, and 3 in year t.

I adjust all financial aid and earnings data to be in constant 2013 dollars for comparability. Importantly for this study, students employed by universities are not included in reporting for the Unemployment Insurance system. However, the financial aid data include total Federal work-study compensation, which is added to the UI earnings data. I discuss the implications of the unavailability of non-work-study earnings at colleges in Section VI and in Appendix A.4. I winsorize the wages at the 99th percentile to avoid issues with outliers.

The primary sample consists of seniors who were enrolled at a public university in Texas in the year they turned 24. This sample restriction would bias the results if students change their enrollment due to financial independence. In Section VI, I check for this issue and find that students do not change their enrollment in the year they turn 24 due to financial independence. The sample is also restricted to seniors because students with different classifications have different expected graduation dates. The restriction to seniors keeps 71.5 percent of students turning 24.[17] Section VI.D considers freshman, sophomores, and juniors separately.

Table 1 contains summary statistics for university seniors. University seniors receive a substantial amount of financial aid, receiving over $2,100 in grants and taking out over $4,100 in

loans. Graduation is relatively common for these students, as 44 percent of seniors who turn 24 graduate in that year and 70 percent graduate by the end of the following year. Also, 30 percent of students received a Pell Grant in the previous year, and students attempted an average of 22 credits hours within the current year.

I focus on university students in this paper because they see much larger changes in financial aid resulting from financial independence than do community college students. This is possibly because community college students file the FAFSA at lower rates than university students. Results for community college students find no effect on persistence, graduation, GPA, or earnings in college.[18]

V. Identification

I leverage the discrete change in the probability of being financially independent arising due to the January 1 cutoff to examine the effect of additional financial aid in a regression discontinuity framework. The outcomes considered include reenrollment, graduation, credits attempted, financial aid, any employment, and annual earnings.

The basic intuition is to compare otherwise similar students who differ in whether they are classified as financially independent. Specifically, the intuition is to compare students born just before January 1 to students born just after January 1 in the year they turn 24. In order to accomplish this, the estimating equation is

$$Y_i = \theta \cdot 1(\widetilde{age}_\iota > 0) + \gamma \cdot \widetilde{age}_\iota + \eta \cdot \widetilde{age}_\iota \cdot 1(\widetilde{age}_\iota > 0) + \boldsymbol{X_i\beta} + \mu_t + \varepsilon_{it}, for\ |\widetilde{age}_\iota| < j \quad (1)$$

where *i* indexes students and *t* indexes school year. Equation 1 is estimated using ordinary least squares. Y_i is a student outcome. $\widetilde{age}_\iota$ is the running variable and is a student's age in days. $\widetilde{age}_\iota$ is recentered so that a student who turns 24 on January 1 is zero.[19] The running variable $\widetilde{age}_\iota$ is controlled for using a local linear approximation.[20] I allow the slope of the running variable to vary above and below the discontinuity. $1(\widetilde{age}_\iota > 0)$ is an indicator for being 24 before January

1. θ is the parameter of interest and is the effect of the additional financial aid arising from students being declared financially independent because of their age.[21] $\boldsymbol{X_i}$ is a vector that contains indicators for race and gender, and μ_t represents year fixed effects. Finally, ε_{it} is an idiosyncratic error term. Standard errors are clustered on age to account for correlation within date of birth (Lee and Card 2008).

This equation is estimated on a subset of the data to compare students who are similar ages. Specifically, restricting to students with $|\widetilde{age_i}| < j$ means that students whose birthdays fall within *j* days of January 1 are included in estimation. *j* is chosen using the procedure outlined in Imbens and Kalyanaraman (2012) for local linear regression discontinuity frameworks, though results are robust to the choice of bandwidth.[22]

A. Assumptions for Identification

There are two assumptions that must be made for Equation 1 to yield unbiased estimates of the effect of age-based financial independence. First, students must not respond to additional financial aid in the year they turn 24 by changing their decision to enroll in that year. Second, birth date cannot be manipulated to gain access to treatment. If either differential enrollment or birth date manipulation occurs, this would appear as additional students who are 24 years old or older before January 1.

If students anticipate the additional financial aid available to independent students, they may change their enrollment or reenrollment. If enrollment is affected, then conditioning the sample on students who turn 24 will yield biased estimates that conflate the effect of additional financial aid on enrolled students and the change in sample composition arising from aid-induced enrollment.

Students do not appear to alter their enrollment decisions in the year they turn 24 based on financial independence. I examine the reenrollment probabilities of 23-year-old students in Figure 1 and Table 2. Because I focus on seniors, reenrollment is how financial aid would affect enrollment. If financial independence altered enrollment decisions, it would appear as a discrete change in the reenrollment probabilities of 23-year-old students at the January 1 cutoff. The estimated discontinuity in reenrollment probability is 0.0027 with a standard error of 0.0038.[23] Figure 1 shows no apparent discontinuity in the probability of reenrollment for 23-year-old students. This can also be seen in Figure 2, Panel B, in which there is no discontinuity in the density of students enrolling in the year they turn 24.

The lack of a response may be because the age rule governing independent status and the consequence of financial independence are not widely known. It may also be that older students do not change their reenrollment based on financial aid. Because there is no measured effect on reenrollment, I continue to condition the sample on enrollment in the year a student turns 24. This lack of a reenrollment effect allows an examination of the effect of financial aid for inframarginal students.

A second assumption for identification is that birth date is not manipulated to gain access to financial independence. Obviously, a student's true birth date is not manipulable by the student. Students do have incentives to misreport their birth date to gain additional aid, but the reported birth date is verified by comparison with Social Security Administration records. Students cannot manipulate their birth date, but parents may manipulate their child's birth date. There is evidence that birth dates around January 1 are manipulated by parents in response to tax incentives (LaLumia, Sallee, and Turner 2015; Schulkind and Shapiro 2014). This issue is

discussed in Appendix A.2 and is found to likely affect only a very small number of students born within a few days of January 1.

To avoid any issues associated with potential retiming of births, the preferred specification will be a regression discontinuity "donut" estimator in which the three days on either side of January 1 are omitted (Almond and Doyle 2011). The results are quantitatively and qualitatively very similar if three days before and after January 1 are included; these results are presented in Table A2 in the Appendix. A formal McCrary test, after excluding three days before and after January 1, yields a point estimate of –.015 with a standard error of .013 (McCrary 2008).[24]

Section A.3 in the Appendix and Table A3 confirm that predetermined student characteristics do not change discontinuously at the threshold.

The testable assumptions of the regression discontinuity estimator are satisfied because (1) there is no change in reenrollment probabilities for 23-year-olds, (2) students are unable to manipulate their date of birth, and (3) observed covariates do not vary discretely by eligibility status. Hence, the results can be interpreted as the causal impact of age-based financial independence on student outcomes for inframarginal students.

VI. Results

A. Educational Outcomes

University students see substantial changes in financial aid arising from financial independence. This is documented in Figure 3 and Table 3. Students who are financially independent appear on the right of the figures and receive an additional $966 in grant dollars, the bulk of which comes in the form of increased Pell Grants ($806). They also take out an

additional $486 in loans. Between grants and loans, this represents a significant change to student finances, totaling over $1,452.

Interpreting the effect on loans requires an important caveat. The data do not contain private loans but do contain federal loans as well as state loans such as the College Access Loan (CAL). Federal loans are by far the most common type of loan and typically offer better interest rates than private loans.[25] As a result, some of the increase in the amount of federal and state loans could be students switching from private loans to federal and state loans. If financial independence caused switching from private loans to federal and state loans, then the estimated increase in loan aid would overstate the change in loan amounts. Because the increase in federal loans ($864) is larger than the increase in both state and federal loans ($485), federal loans appear to crowd out state loans, but not completely.

This large change in financial aid allows an examination of whether student outcomes are affected by financial aid. The effect on student outcomes is presented in Figure 4 and Table 3. Financial independence increases students' attempted credit hours by 0.39. In attempting more credits, students could see their GPA decrease if they do not change the time devoted to studying. However, despite the larger class load, student GPAs are unaffected, with an estimated discontinuity of 0.001 and a 95-percent confidence interval of –0.022 to 0.025.

Students are 1.8 percentage points more likely to graduate in the year they turn 24 (in the tables this is designated "Grad 4yr This Year") as a result of additional financial aid. This is seen in Figure 4 and in Table 3. This discontinuity is clearly visible in the figure and is statistically different from zero at the 1-percent level. There is an accompanying dip in the probability of enrolling in the next year, which provides evidence that financial aid caused some students to graduate and therefore not enroll the next year.

The increase in graduation caused by aid could either be permanent or transitory. Additional aid could cause students to graduate who otherwise would not have, or cause students to graduate earlier than they would have absent additional aid. To determine whether the measured change in graduation is permanent or transitory, I consider graduation in either the year students turn 24 or the year after. The estimated coefficient (labeled "Grad 4yr Next Year" in the table) is 0.002, which suggests that additional financial aid retimed graduations rather than induced graduation among students who would not have graduated.

There is a positive effect of additional aid on graduation, but it is relatively small. The 1.8-percentage-point increase represents a 4-percent increase in the graduation rate during the school year a student turns 24. The increase comes at a cost of $966 in grants and $485 in loans. The Congressional Budget Office estimates that loans originating in 2017 have a subsidy of 10.32 percent (Congressional Budget Office 2017).[26] Using this subsidy rate for loans results in a cost of $50.13 in addition to the $966 in grants. These estimates imply that it costs $58,099 for one student to graduate one year earlier. College enrollees in the sample earn $12,219, and students who graduate in the year they turn 24 earn $26,923 in the year they turn 25. This means that graduating a year earlier corresponds to roughly a $14,704 difference in earnings. On average, the benefits of an additional year in the labor market do not exceed the costs associated with graduating a year earlier. However, Section VI documents heterogeneity in cost-effectiveness for different levels of family income.

B. Mechanisms

I now investigate mechanisms for the increased credits attempted and reduced time-to-degree, including reduced time spent working during college and binding credit constraints.

1. Labor supply during college

Despite the large number of students in the labor force and the large amount of federal financial aid available, very few studies have attempted to identify the effects of financial aid on student earnings. Broton, Goldrick-Rab, and Benson (2016) use random assignment of a state need-based grant and find that students receiving financial aid report that they reduced hours worked by 14 percent. Scott-Clayton (2011) examines the effect of a merit scholarship in West Virginia that affected enrollment and finds that scholarships reduce earnings in some specifications but not in others.[27]

Additional financial aid may allow students to reduce time spent working. I explore whether additional aid affects earnings in Figure 5 and Table 3. Financially independent university students do not adjust the probability of positive earnings. The coefficient on whether students have positive earnings is –0.5 percentage points with a standard error of 0.5 percentage points. This rules out reasonably small reductions in the probability of positive earnings up to –1.5 percentage points. Despite no change in the probability of working, there is a significant change in earnings during college seen in Figure 5, Panel B. Students who are financially independent by age 24 see their earnings decrease by $511.

Interpreting the change in earnings requires caution. In Table A4, I perform a placebo exercise where I use the same specifications except I examine students turning 21, 22, or 23 during the school year. For the 22- and 23-year-old samples, there are discontinuities in earnings of $162 and $220 respectively that are significant at the 5-percent level. These two placebo exercises are the only two that are significant at the 5-percent level. 21-year-old students do not see reduced earnings at the threshold. Because this occurs for both 22- and 23-year-old students, these discontinuities are not likely to be the result of gaming eligibility to ensure additional aid. Additionally, the effects on earnings are somewhat sensitive to the choice of bandwidth, as can be

seen in Figure 6, with smaller bandwidths yielding smaller, insignificant effects on earnings. Given the sensitivity to bandwidth and the issues in the placebo test, I interpret the evidence on earnings as being suggestive of declines in earnings due to additional aid.[28]

2. Credit constraints

Financial aid may reduce time-to-degree because it eases binding credit constraints. This paper tests whether increased financial aid eases credit constraints. Many studies have attempted to identify whether binding credit constraints affect college enrollment and graduation. Early studies tended to find that credit constraints were not prevalent (Cameron and Heckman 1998; Cameron and Taber 2004; Carneiro and Heckman 2002; Keane and Wolpin 2001). However, recent studies have shown that borrowing constraints matter for educational investment (Belley and Lochner 2007; Brown, Scholz and, Seshadri 2012; Cowan 2016; Lovenheim 2011; Stinebrickner and Stinebrickner 2008).

Independent students have access to higher yearly and aggregate federal student loan limits than dependent students have. This provides an opportunity to test for credit constraints among enrolled college students. Specifically, how does financial independence affect the number of students borrowing above the amount that would have been allowed had they been born a few days later?

Figure 3 and Table 3 investigate this question. Panel C shows that there is a 15 percentage point increase in the number of students borrowing more federal loans than the dependent maximum. This suggests that 15 percent of students face binding credit constraints and that financial independence eases their credit constraints by raising their borrowing limit. This estimate is similar in magnitude to Stinebrickner and Stinebrickner (2008).

There are three important caveats for the estimation of the number of students who are credit constrained: private loans, changes in grant aid, and behavioral factors. As previously discussed, the bulk of student loans are federal loans that offer relatively attractive interest rates. As a result, students are likely to exhaust their federal loan eligibility before turning to private loans. In the 2012 National Postsecondary Student Aid Study (NPSAS), 9.6 percent of students who reported taking out less than the statutory maximum of federal student loans reported having taken out private loans, which suggests that nearly all students will exhaust federal student loan eligibility before taking out private loans.

Financial independence not only changes the maximum amount of loans students have access to but also increases grants and eligibility for subsidized loans. To partially address this issue, I will include, in the section on heterogeneity, an examination of students who had received a Pell Grant or a zero EFC in the previous year. These students see smaller (or no) changes in grants and subsidized loans, and as a result, they can inform what might happen if subsidized loans and grants were unchanged. Results are similar for students who see no changes in grant aid.

Loan take-up has been shown to depend on the amount of the loan offer. Financial independence increases the default loan offer due to a higher yearly maximum for independent students. Marx and Turner (2016) use a randomized controlled trial and demonstrate that the default of packaging the maximum loan amount affects loan take-up. The results from Marx and Turner (2016) suggest that behavioral factors complicate the measurement of credit constraints.

The measure of credit constraints employed in this paper is imperfect. However, borrowing more than the dependent maximum is a necessary condition for credit constraints. Using this measure, I find evidence that additional aid eases binding credit constraints.

C. Heterogeneity

I examine heterogeneity by a measure of parental income, which affects the size of the change in financial aid. In Table 4, separate discontinuities are estimated for three groups of students: (1) students who had a zero EFC when they were 23 years old, (2) students who received a Pell grant when they were 23 years old, and (3) students who did not receive a Pell Grant when they were 23 years old. These groups are examined separately because financial independence has heterogeneous impacts on financial aid depending on family income.

Students who previously received a zero EFC are examined in Column 1 of Table 4 and see no change in grants or subsidized loans. These are the neediest students in the sample, so the exclusion of parental income and assets does not affect their eligibility for grants or subsidized loans. However, these students do increase borrowing by $723. Despite seeing an increase only in student loans, age-induced financial independence causes 4 percent of students to speed up graduation by one year. The larger effect on graduation is somewhat surprising given the lack of a change in grants. However, the increased loans are likely to help these students most because they are the neediest in the sample.

The second column examines students who received a Pell Grant when they were 23.[29] Due to financial independence, these students see a $374 increase in grants and a $727 increase in total loans. This aid causes 2.85 percent of students to graduate one year earlier, which is a larger point estimate than for the sample as a whole. These students also appear to be credit constrained at slightly higher rates as compared to the sample as a whole.

The third column of Table 4 examines students who did not receive a Pell Grant when they were 23 years old. These students's parents generally are wealthier, so excluding parental income induces larger changes in need-based financial aid. They see a $1,232 increase in grants

and a $370 increase in loans. Despite a much larger change in grant aid, the effect on time-to-degree is smaller, with 1.3 percent reducing time-to-degree by one year, though this is not statistically significant.

The heterogeneity analysis shows that the cost of reducing time-to-degree by one year varies by family income. For students who had previously received an EFC of zero, there is no direct cost from grants. Hence, the increase in loans for independent students reduces time to graduation. Essentially, this decreased time-to-degree (and increased time in the labor market) comes at the cost of administering student loans. Using the subsidy rate for student loans of 10.32 percent implies a total subsidy of $74.6 for students who previously received a zero EFC (Congressional Budget Office 2017). Hence, reducing time-to-degree by one year for one student costs $1,883. This cost is significantly smaller than the difference in earnings for recent college graduates versus enrollees.

For students who had previously received a Pell Grant, an additional $15,743 in grants and loan subsidies decreases time-to-degree by one year. This is very similar to the higher earnings of graduates compared to the earnings of students enrolled in college. For students who had previously received a Pell Grant, additional grant aid is likely to be efficient, because its cost is roughly equal to the earnings gained from an additional year in the labor market. For students who had not previously received a Pell Grant, reducing time-to-degree by one year costs $101,598 in grants and loan subsidies, which is substantially more costly than the benefit of an additional year in the labor market.

Taken together, the results on heterogeneity by previous Pell receipt suggest that financial independence gives more resources to relatively wealthier students. Despite this, the reduced time to graduation seems to be larger for needier students. In fact, aid is likely to be efficient when

given to students who qualified for the Pell Grant in the year they turned 23, because the benefits to the students are less than or equal to the costs. These results on heterogeneity highlight the educational attainment benefits of targeting financial aid to the neediest students.

D. Other Classifications

The focus of this paper is on seniors turning 24 during an academic year. However, the same change in independent status occurs for students who are not seniors. These students are considered in Table 5. There are very few students turning 24 as freshman, and in consequence, the presented results are imprecise.

There are more sophomores and juniors turning 24, which results in more precise estimates. In both cases, students are more likely to persist to the next year. Sophomores are 7.9 percentage points more likely to persist, and juniors are 2.6 percentage points more likely to persist. Juniors also attempt .51 more credit hours. Student earnings are not affected for freshman, sophomores, and juniors, although the estimates are imprecise.

These students provide evidence that additional financial aid benefits students before their senior year. Although 24-year-old students are a particular sample, this shows that financial aid affects older students who are not as far along in their schooling.

E. Robustness

Two additional robustness checks are performed to make sure the results are not spurious. First, Figure 6 checks the choice of bandwidth. Panel A considers graduation. Each of the dots represents an estimated discontinuity, along with 95-percent confidence intervals for different bandwidth choices. For graduation in the year students turn 24, the estimate is stable across bandwidths and is statistically different from zero, starting with the bandwidth of 80 days.

For earnings, smaller bandwidths tend to deliver smaller estimates, but once the bandwidth includes 90 days, the estimates are statistically different from zero. This figure shows that the effect on earnings is somewhat sensitive to the choice of bandwidth.

Panel C shows that there are no bandwidths where the estimate for reenrollment among 23-year-olds is statistically significant. The point estimates decline slightly with larger bandwidths, but overall, the majority of the evidence suggests that reenrollment (and thus selection into the estimating sample) was not affected.

Second, I use students turning 21, 22, and 23 as placebo exercises to see whether student outcomes systematically vary at January 1. These results are presented in Table A4 and are discussed in Section A.5 of the Appendix. If students anticipated the change in financial aid, there would likely be changes in student outcomes. However, student outcomes do not significantly differ at this same threshold for other ages, with the exception of earnings as previously discussed.

VII. Discussion and Conclusion

This paper links three trends in higher education: (1) higher tuition, (2) increasing time-to-degree, and (3) increased earnings in college. In particular, the price of tuition causally increases time-to-degree, and I present suggestive evidence that it increases student labor supply. The effects of college price on inframarginal students are important because they affect many students and are implicitly included in every financial aid and tuition policy but are rarely directly measured.

Several policy lessons emerge from this paper. First, proposals to change tuition or financial aid should consider the implications for time-to-degree for inframarginal students. Second, the change in financial aid associated with financial independence is poorly targeted.

The largest increases in aid go to students who come from the most affluent backgrounds. As a result, the benefits from the change in independence (namely, one additional year in the labor market) do not outweigh the costs for the sample as a whole. However, for poorer students, who see smaller changes in aid, the effects on time-to-degree are larger and likely efficient. For students who had previously had a zero EFC, time-to-degree is reduced simply by allowing additional borrowing of unsubsidized loans.

The heterogeneous effects of financial aid by family income underscore how targeting financial aid to needier students improves student outcomes relative to aid for wealthier students. This targeting could largely be accomplished through relatively little information on student background (Dynarski Scott-Clayton 2006). This insight is particularly important for evaluating policy that reduces tuition for all students.

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[1] I refer to these students as inframarginal because their initial enrollment decisions are not affected by financial aid.

[2] 18.6 percent of students who are 23 to 24 years old are financially independent (author's calculations; National Center for Education Statistics 2012).

[3] Targeting can also have costs that are disproportionately born by poorer students (Dynarski Scott-Clayton 2006). However, Dynarski Scott-Clayton 2006 demonstrates that dramatically reducing the amount of information collected for the purpose of targeting would retain the ability to target low-income students.

[4] Since 1982, the average amount for total tuition, fees, and room and board has increased by over 350 percent after adjusting for inflation (National Center for Education Statistics 2013).

[5] The rise in student work has been examined in Scott-Clayton (2012), and the author concludes that different factors have driven the growth at different times.

[6] Some papers have considered merit aid which gives awards based on academic achievement (Dynarski 2003, 2008; Scott-Clayton 2011; Cohodes and Goodman 2014; Scott-Clayton and Zafar 2016; Sjoquist and Winters 2012). Other programs have considered need-based aid that uses financial need as the criteria for assigning aid (Castleman and Long 2016). And still other programs have elements of both need- and merit-based aid (Angrist et al. 2014; Bettinger et al. 2016). The current paper considers need-based aid. Most papers have found positive effects on graduation, but some have found negative effects (Cohodes and Goodman 2014).

[7] Anderson and Goldrick-Rab (2016) find that additional aid at community colleges did not help enrolled students persist or graduate.

[8] College dropout is uncommon in the United Kingdom. Instead, degrees have final grades indicating a student's performance. Murphy and Wyness (2016) examine the probability of receiving a First Class or Upper Second Class degree, which are colloquially known as "good degrees."

[9] Bettinger (2004) examines the effect of Pell Grants conditional on enrollment, but the results are sensitive to specification. Additionally, Bettinger (2015) discusses the effect of financial aid on enrolled students by making assumptions about the behavior of marginal versus inframarginal students. Garibaldi et al. (2012) examine Bocconi University in Italy, which is notably a different setting from public universities in the United States or, specifically, Texas. Moreover, the policies are different, as Garibaldi et al. (2012) examine anticipated discontinuities in tuition whereas the present study examines changes in financial aid that are likely to be unanticipated. The differences in these settings may lead to different graduation responses to college price.

[10] Barr (2015) also examines nontraditional students by studying the Post-9/11 GI Bill and finds that additional aid increases enrollment.

[11] Alternatively, the comparison is across ages within cohorts.

[12] Seftor and Turner (2002) examine the effect on students ages 21 to 23, where the present study focuses on students ages 23 to 24.

[13] If a life event occurs that would change a student's Expected Family Contribution (EFC), students can amend their FAFSA to reflect the new information and possibly change their eligibility for need-based aid.

[14] See http://studentaid.ed.gov/fafsa/filling-out/dependency for all conditions that determine independent status.

[15] The financial aid data has broadening coverage over time. From 2003 to 2006 the data include financial aid for students who received any need-based aid; from 2007 to 2009 they include financial aid for all students who filed a FAFSA; and from 2010 to the present they also include financial aid for students who received only merit-based or performance-based aid.

[16] The unemployment insurance records include only employers who pay at least $1,500 in gross wages to employees in a quarter. Alternatively, employers are included if an employer has at least one employee during 20 different weeks in a calendar year, regardless of the wages.

[17] The restriction to seniors is akin to the standard practice of examining rising freshman. It ensures that the outcomes considered have a similar meaning. For example, graduation within one year is a relevant outcome for seniors but not for freshman. Moreover, since over 70 percent of students turning 24 in a school year are seniors, seniors are the most natural group of students to examine. However, examining all students yields similar results. The effects on graduation are attenuated, as expected, but are still marginally statistically significant. These results can be obtained from the author upon request.

[18] These results are not presented but are available upon request. Detecting economically meaningful changes in outcomes for community college students is difficult due to the relatively small change in financial aid arising from financial independence.

[19] For example, a student born on December 31 would have $\widetilde{age_i} = 1$.

[20] This is equivalent to estimating the relationship between Y_i and $\widetilde{age_i}$ nonparametrically using a rectangular kernel (Imbens and Lemieux 2008).

[21] Some students who are less than 24 will be independent for other reasons, as previously discussed.

[22] Tests for sensitivity to bandwidth will be presented in Section VI. In practice a bandwidth of 100 days is used for all outcomes except for credits attempted where a bandwidth of 200 days is used.

[23] The robustness of this estimate to various bandwidths is checked later.

[24] Including students within three days of January 1 yields an estimate of .054 with a standard error of .010. This discontinuity is seen in Figure 2 but is notably absent when excluding the three days before and after January 1.

[25] Private student loans make up about 10 percent of student debt issued since 2009 (College Board 2015). Federal loans also offer access to a variety of repayment plans generally unavailable in the private market. These repayment plans include income-based repayment, income-contingent repayment, graduate repayment, and extended repayment.

[26] This estimate is imperfect because it applies the subsidy rate for all federal loans regardless of the type of loan, type of institution, classification of student, etc. Additionally, the estimated change in loans combines the subsidy on subsidized, unsubsidized, and state loans.

[27] The sensitivity to specification in Scott-Clayton (2011) may be because the identification strategies measure different local average treatment effects or because there is a bias in one or both of the estimates arising from those strategies. Also, Scott-Clayton and Park (7) use a regression discontinuity to examine the effect of replacing federal loans with Pell Grants for community college students and find that grants reduce earnings and increase full-time enrollment. However, there is a discontinuity in the density of the running variable, which suggests the results may be

biased.

In related work, many studies have tried to quantify the effect of working on educational outcomes. The general finding has been that working in college decreases GPA (Kalenkoski and Pabilonia 2010; Stinebrickner and Stinebrickner 2003) and credits accumulated (Darolia 2014; Triventi 2014). These studies motivate researching the effect of financial aid on labor supply. The financial aid–induced reductions in earnings and accelerated graduation results in this paper are consistent with the aforementioned prior studies on the effects of employment on student outcomes.

[28] Interpreting the estimates of the effect of additional financial aid on earnings requires additional caution, because earnings for students employed by the university they attend are not included in UI earnings records unless the students are employed as part of the federal work-study program. There is further discussion of on-campus employment in Section A.4 of the Appendix, but if anything, the lack of on-campus, non-work-study earnings likely results in an underestimate of the effect of financial aid on earnings.

[29] Students with a zero EFC in the year they turned 23 are a subset of this sample.

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Figures and Tables

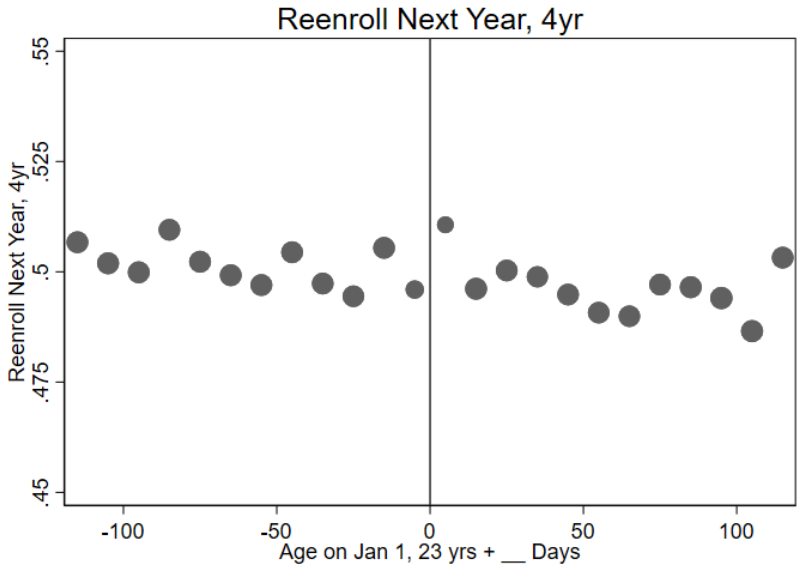


Figure 1
Reenrollment of 23-Year-Olds

Note: This figure plots the fraction of 23-year-olds who reenroll in the year they turn 24 by their recentered birth date. The horizontal axis is recentered age in days such that a student who is 24 years old on January 1 is zero. The data come from administrative records of the THECB and include the 2002–2003 to 2013–2014 school years.

(a)4yr (b) 4yr Donut

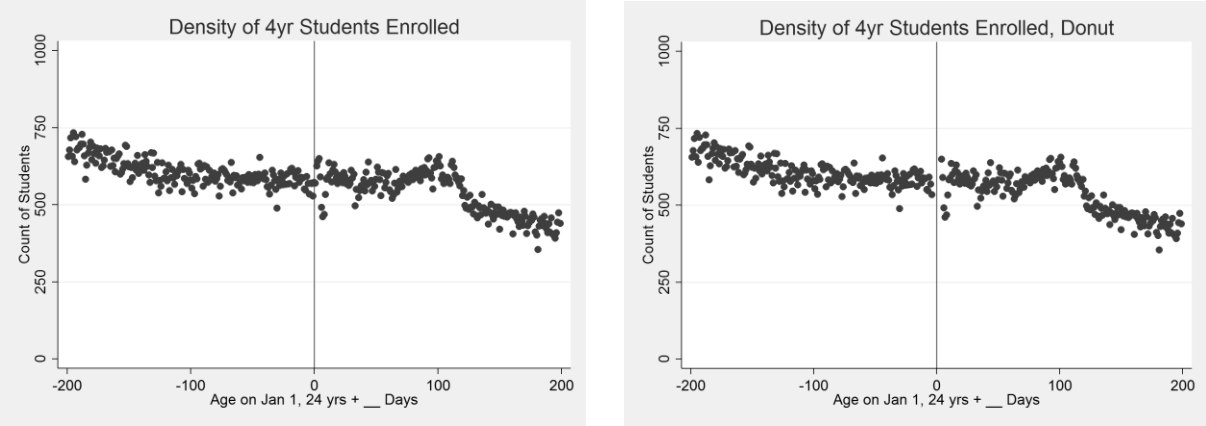
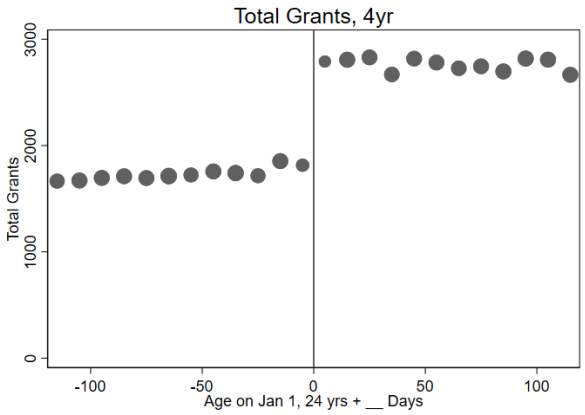


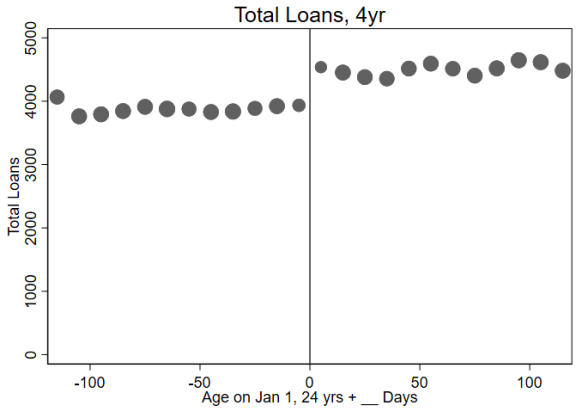
Figure 2
Density of Birth Dates

Note: Panel A plots the number of students born on each day of the year, and Panel B replicates that plot but removes students born three days before or after January 1. The horizontal axis is recentered age in days such that a student who is 24 years old on January 1 is zero. The data come from administrative records of the THECB and include the 2002–2003 to 2013–2014 school years.

(a) Grants



(b) Loans



(c) Borrow More than Unsub. Max

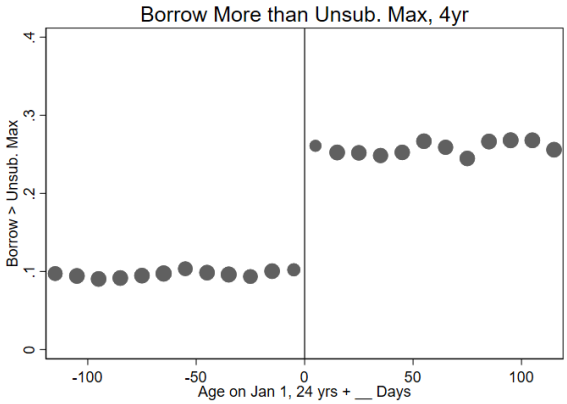


Figure 3
Four-Year Colleges, Financial Aid

Note: Panel A plots the average amount of grants received by students by their age as of January 1. Panel B plots the amount of loans taken out by the students, and Panel C plots the fraction of students who borrow above the annual federal maximum for dependent students. The horizontal axis is recentered age in days such that a student who is 24 years old on January 1 is zero. Each dot represents the average for a group of ten birth dates. The size of the dot is proportional to the number of students for which the average is computed. The data are from administrative records of the THECB and include the 2002–2003 to 2013–2014 school years.

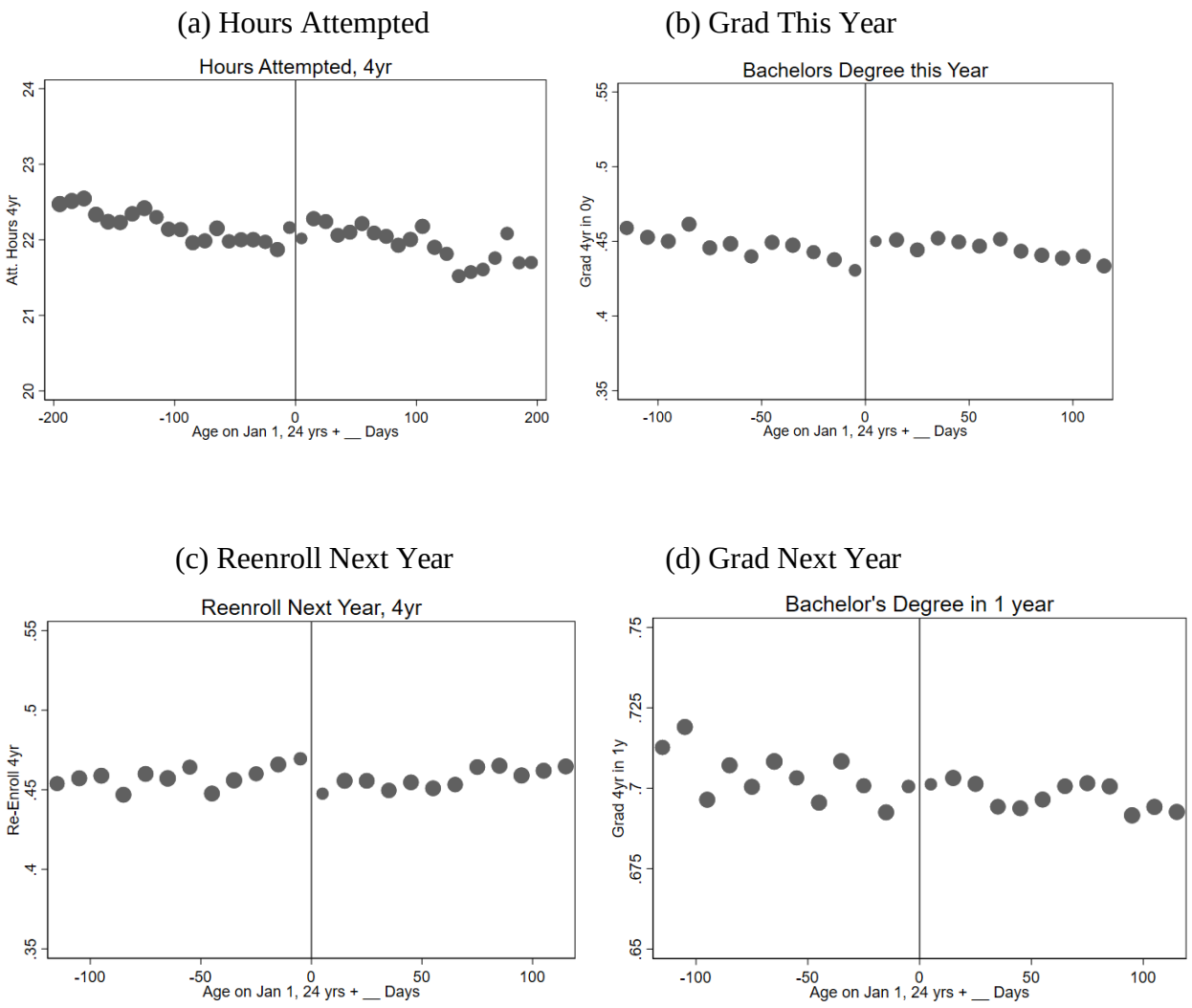


Figure 4
Four-Year Colleges, Educational Outcomes

Note: Panel A plots the number of credit hours attempted by student age as of January 1. Panel B plots the probability of graduating in the year a student turns 24 by birth date. Panel C plots the probability of reenrolling in the year after a student turns 24 by birth date. Panel D plots the probability of graduating by the year after a student turns 24 by birth date. The horizontal axis is recentered age in days such that a student who is 24 years old on January 1 is zero. Each dot represents the average for a group of ten birth dates. The size of the dot is proportional to the number of students for which the average is computed. The data are from administrative records of the THECB and include the 2002–2004 to 2013–2014 school years.

(a) Employment (b) Earnings

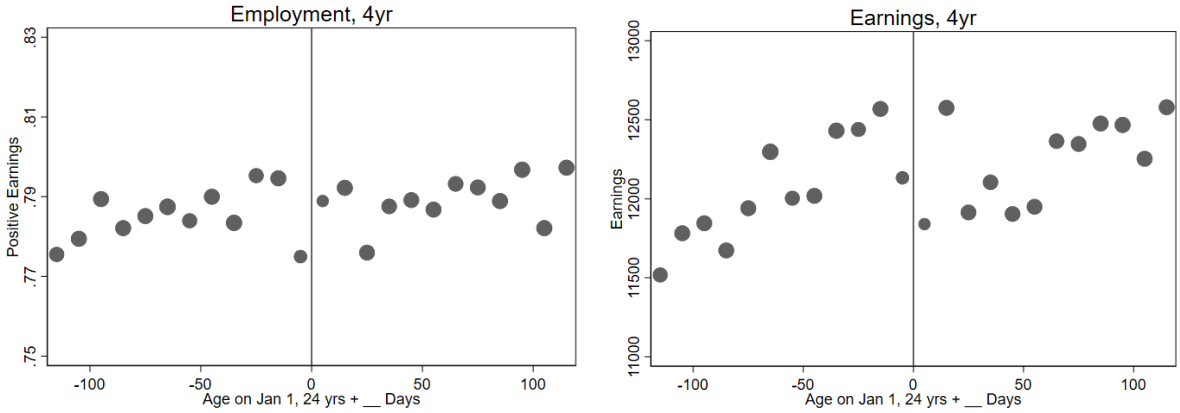
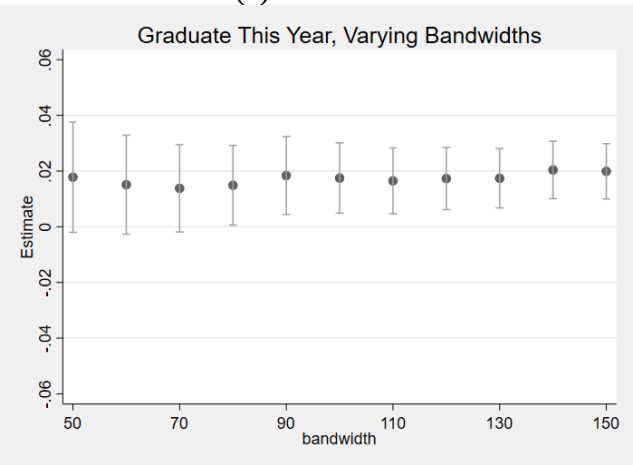


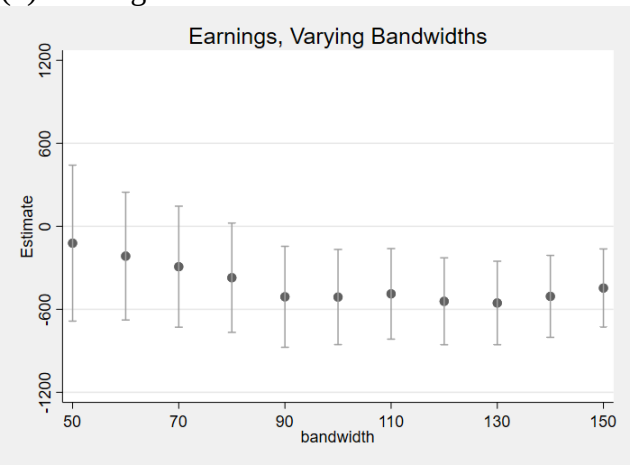
Figure 5
Four-Year Colleges, Earnings Outcomes

Note: Panel A plots the fraction of students with nonzero earnings in the year they turn 24 by their age as of January 1. Panel B plots earnings during the school year a student turns 24 by birth date. The size of the dot is proportional to the number of students for which the average is computed. The horizontal axis is recentered age in days such that a student who is 24 years old on January 1 is zero. The data come from administrative records of the TWC and include the 2002–2003 to 2013–2014 school years.

(a) Graduation



(b) Earnings



(c) ReEnroll when 23

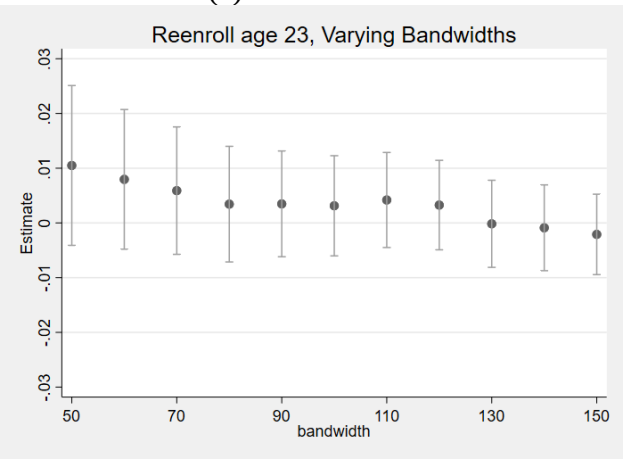


Figure 6
Bandwidth Sensitivity, University Students

Note: Each dot is an estimated discontinuity for students who turn 24 on January 1. Each estimate is plotted with 95-percent confidence intervals. The horizontal axis shows the bandwidth used for each estimate. Panel A plots the effect of independence on graduation in the year students turn 24. Panel B plots the estimate of independence on earnings. Panel C plots the estimate of reenrollment for 23-year-old students. The data are from administrative records of the TWC and THECB and include the 2002–2003 to 2013–2014 school years.

Table 1
Summary Statistics

Variable	Obs	Mean	Std. Dev.
Male	227,848	0.49	0.50
White	227,848	0.49	0.50
Black	227,848	0.10	0.30
Hispanic	227,848	0.30	0.46
Asian	227,848	0.05	0.21
Hours attempted	227,848	22.09	10.36
Enroll next year	227,848	0.46	0.50
Graduate current year	227,848	0.44	0.50
Graduate by next year	227,848	0.70	0.46
GPA	227,848	2.70	0.97
Borrow at unsub max	227,848	0.06	0.24
Borrow at sub max	227,848	0.12	0.32
Borrow more than unsub max	227,848	0.17	0.38
Total grants	227,848	2,168.59	3,125.50
Pell	227,848	1,449.67	2,111.72
Total loans	227,848	4,155.84	5,421.51
Received Pell last year	227,848	0.30	0.46
Earnings	227,848	12061.83	12424.1
Positive earnings	227,848	0.79	0.41

Note: This table presents summary statistics for the sample of seniors at Texas public universities from 2002–2003 to 2013–2014 who are within 200 days of turning 24 on January 1. The data are from administrative records of the THECB and TWC and include the 2003–2004 to 2013– 2014 school years. The reference year for variables is the school year a student turns 24. For instance, "Graduate by next year" refers to graduation by the school year a student turns 25. Earnings correspond to earnings for the academic year (Q4 in year *t*-1 and Q1, Q2, and Q3 in year *t*).

Table 2
Reenrollment Probability of 23-Year-Old Students

	Reenroll 4yr
Discontinuity	0.0027
	(0.0038)
Mean | Ineligible	0.5
Observations	257,723

Note: This table presents estimates of the change in the probability of reenrolling in the next school year for students who turn 23 during the current school year. The discontinuity is for students whose birthdays are on January 1. Students born December 29 through January 3 are excluded, as discussed in the text. The discontinuity is estimated using a window of birth dates of 100 days from January 1. "Mean | Ineligible" is the estimated value of the dependent variable at the discontinuity for ineligible students. The regression is a modified version of Equation 1 considering students in the year they turn 23. The regression includes controls for gender, race, linear effects of recentered age in days allowed to vary on either side of the cutoff, and year fixed effects. Standard errors are clustered on recentered birth date and are in parentheses, with *p < 0.1 **p < 0.05 ***p < 0.01.

Table 3
Estimated Discontinuities

	Total Grants	Unsub. Loans	Sub. Loans	Pell Amount	Total Loans	Borrow > Unsub. Max
Discontinuity	966.6***	303.6***	560.7***	806.0***	485.8***	0.149***
	(37.77)	(36.53)	(27.80)	(20.64)	(71.42)	(0.00484)
Mean | Ineligible	1812.2	1296.8	1568.9	1139.4	3908.5	0.101
Observations	111,795	111,795	111,795	111,795	111,795	111,795
	Att. Hours	Reenroll 4yr	Grad 4yr This Year	Grad 4yr Next Year	GPA	
Discontinuity	0.391***	-0.0147**	0.0175***	0.00187	0.00126	
	(0.0883)	(0.00617)	(0.00646)	(0.00579)	(0.0119)	
Mean | Ineligible	21.87	0.464	0.435	0.699	0.2695	
Observations	223,772	111,795	111,795	111,795	111,795	
	Earnings	Next Year Earnings	Positive Earnings			
Discontinuity	-511.3***	-437.7	-0.00531			
	(175.6)	(269.6)	(0.00506)			
Mean | Ineligible	12369.5	20634	0.551			
Observations	111,795	111,795	111,795			

Note: Each column has an estimate of the discontinuity in student outcomes for students born before January 1. The estimates come from estimating Equation 1. The regressions include controls for gender, race, linear effects of recentered age in days allowed to

vary on either side of the cutoff, and year fixed effects. Each discontinuity is estimated using a window of birth dates of 100 days around January 1, except in the case of attempted hours, where a bandwidth of 200 days is used. This bandwidth corresponds to the IK bandwidth. Students born December 29 through January 3 are excluded, as discussed in the text. "Mean | Ineligible" is the estimated value of the dependent variable at the discontinuity for ineligible students. The data are administrative records of the THECB and TWC and include the 2002–2003 to 2013–2014 school years. Standard errors are clustered on recentered birth date and are in parentheses, with *p < 0.1 **p < 0.05 ***p < 0.01.

Table 4
Heterogeneity Analysis

	Previous 0 EFC	Previous Pell	Previous No Pell
Total Grants	-129.0	373.6***	1231.7***
	(101.5)	(71.31)	(33.45)
Mean | Ineligible	4975.2	4411.2	659.1
Total Loans	723.3***	727.7***	370.9***
	(155.1)	(121.2)	(83.73)
Mean | Ineligible	5256.6	5486.7	3208.4
Grad 4yr in 0y	0.0396***	0.0285***	0.0125
	(0.0137)	(0.0108)	(0.00762)
Mean | Ineligible	0.406	0.433	0.437
Grad 4yr in 1y	0.0135	0.00871	-0.00122
	(0.0145)	(0.0105)	(0.00644)
Mean | Ineligible	0.694	0.712	-0.00122
Earnings	-495.0	-507.1*	-520.1**
	(352.9)	(261.1)	(204.2)
Mean | Ineligible	11368.9	11539	12737.6
Borrow > Unsub. Max	0.162***	0.174***	0.137***
	(0.0129)	(0.00997)	(0.00481)
Mean | Ineligible	0.19	0.184	0.0643
Observations	18,995	33,844	77,951

Note: Each entry is an estimate of the discontinuity in student outcomes for students born before January 1. Columns represent different subsamples used in estimation and refer to whether a student had a zero EFC, received a Pell grant, or did not receive a Pell grant in the year he or she turned 23. The estimates come from estimating Equation 1. The regressions include controls for gender, race, linear effects of recentered age in days allowed to vary on either side of the cutoff, and year fixed effects. Each discontinuity is estimated using a window of birth dates of 100 days from January 1. Students born December 29 through January 3 are excluded, as discussed in the text. "Mean | Ineligible" is the estimated value of the dependent variable at the discontinuity for ineligible students. The data are administrative records of the THECB and TWC and include the 2002–2003 to 2013–2014 school years. Standard errors are clustered on recentered birth date and are in parentheses, with *p < 0.1 **p < 0.05 ***p < 0.01.

Table 5
Other Classifications

Freshman	Grants	Loans	Hours	Enroll Next Year	Earn
Discontinuity	157.3	303.9	0.280	0.0132	356.2
	(145.5)	(192.0)	(0.349)	(0.0306)	(757.0)
Mean | Ineligible	1134.1	1741.2	13.94	0.439	10657
Observations	4,687	4,687	9,354	4,687	4,687

Sophomore	Grants	Loans	Hours	Enroll Next Year	Earn
Discontinuity	364.6***	721.1***	0.186	0.0794***	104.4
	(103.3)	(161.2)	(0.242)	(0.0191)	(491.1)
Mean | Ineligible	1577.3	2664.6	16.22	0.58	11953
Observations	11,216	11,216	22,759	11,216	11,216

Junior	Grants	Loans	Hours	Enroll Next Year	Earn
Discontinuity	510.9***	609.7***	0.510***	0.0264**	-116.8
	(68.95)	(121.8)	(0.164)	(0.0108)	(309.1)
Mean | Ineligible	1688.2	3551	18.94	0.739	12265.3
Observations	28,590	28,590	57,809	28,590	28,590

Note: Each entry is an estimate of the discontinuity in student outcomes for students born before January 1. Each panel represents a different sample based on student classification. The estimates come from estimating Equation 1. The regressions include controls for gender, race, linear effects of recentered age in days allowed to vary on either side of the cutoff, and year fixed effects. Each discontinuity is estimated using a window of birth dates of 100 days from January 1 except for hours, which is estimated using a window of 200 days. Students born December 29 through January 3 are excluded, as discussed in the text. "Mean | Ineligible" is the estimated value of the dependent variable at the discontinuity for ineligible students. The data are administrative records of the THECB and TWC and include the 2002–2003 to 2013–2014 school years. Standard errors are clustered on recentered birth date and are in parentheses, with *p < 0.1 **p < 0.05 ***p < 0.01.