The Economic Incidence of Federal Student Grant Aid

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Abstract

The Pell Grant Program provides billions of dollars in subsidies to low-income college students. I estimate the economic incidence of these subsidies using regression discontinuity (RD) and regression kink (RK) designs. The treatment of Pell Grant aid is multidimensional: students receive an additional dollar of Pell Grant aid and are also labeled as Pell Grant recipients. A combined RD/RK approach allows for separate identification of schools' willingness to pay for students categorized as needy and the pricing response to outside subsidies. After accounting for both dimensions, I estimate that 11-20 percent of Pell Grant aid is passed-through to schools. *JEL: H22, I21, I23.*

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1 Introduction

The federal government provides billions of dollars in targeted need-based aid to low-income college students every year. Although students are the statutory recipients of this aid, its economic incidence may fall partially on schools (Fullerton and Metcalf 2002). Specifically, schools may respond to federal student aid by increasing prices faced by recipients, either through tuition increases or reductions in discounts provided through institutional grants and scholarships. Concurrent tuition and student aid increases over the past three decades underscore the importance of evaluating federal aid crowd out (Baum et al. 2015).

In this paper, I measure the economic incidence of the federal Pell Grant Program, the largest source of need-based grant aid in the United States, using student-level data from the National Postsecondary Student Aid Study. On average, institutions capture 15 percent of their students' Pell Grant aid through price discrimination. However, the extent and pattern of capture vary substantially by institutional control and selectivity. Public schools capture less than 5 percent of their students' Pell Grant aid, while decreases in institutional grant aid crowd out over three-quarters of Pell Grant aid received by students in selective nonprofit schools. Incidence also varies across students within some sectors. For instance, Pell Grant aid appears to *crowd in* institutional aid received by Pell Grant recipients attending more selective institutions.

I identify these impacts using discontinuities in the relationship between Pell Grant aid and the federal government's measure of need. The Pell Grant Program's schedule contains discontinuities in both the level and in the slope of aid, resulting in students with similar levels of need receiving significantly different grants. This variation allows for the use of both regression discontinuity (RD) and regression kink (RK) designs (Hahn, Todd and der Klauuw 2001; Nielsen, Sørensen and Taber 2010; Card et al. 2015). My analysis illustrates the relationship between these two methods and provides an example of circumstances under which the parameters identified by RD and RK designs can be combined to identify multiple treatment dimensions.

The RK design relates the change in the slope of the Pell Grant schedule at the eligibility cut-off with the change in the slope of the institutional aid schedule at this same point. RK estimates imply that schools capture 19 percent of Pell Grant aid through price discrimination. The RD approach relates the change in the level of Pell Grant aid at the eligibility cut-off with the change in the level of institutional aid at this same point. RD estimates imply that schools *increase* institutional aid by 57 cents for every dollar of Pell Grant aid. These estimates, and the statistically significant difference between RD and RK estimates, are robust to a variety of specifications and sample restrictions.

I reconcile the conflicting RD and RK estimates through a framework in which the "treatment" of Pell Grant receipt is multidimensional. Students at the margin of Pell Grant eligibility receive an extra dollar of outside aid but are also labeled as Pell Grant recipients, which may change some institutions' willingness to direct resources towards them. I show that under the assumption of locally constant "labeling" effects, it is possible to identify both schools' willingness to pay for Pell Grant recipients and their pricing response to outside subsidies using a combined RD/RK approach.[1]

The RD estimator only identifies the combined impact of these treatment dimensions. Near the Pell Grant eligibility threshold, schools' greater willingness to pay for Pell Grant recipients dominates pass-through of outside grant aid. However, only one-fifth of Pell Grant recipients experience a net decrease in their effective prices, as the pass-through of each additional dollar of Pell Grant aid quickly overtakes schools' willingness to pay for needy students. On average, Pell Grant recipients receive an additional $375 (26 percent increase) in institutional aid due to schools' willingness to pay for needy students, but every additional dollar of Pell Grant aid is crowded out by a 19 cent reduction in institutional aid.

My findings contribute to the literature on the market for higher education, and, in particular, colleges' pricing decisions.[2] I show how variation in schools' response to Pell Grant aid can be rationalized by differences in institutional objectives across sectors. Selective public and nonprofit institutions demonstrate a willingness to pay for students categorized as Pell Grant recipients. In the public sector, net pass-through of Pell Grants is close to zero, but increases in institutional aid for recipients near the eligibility threshold come at the expense of the neediest Pell recipients. Conversely, more selective nonprofit institutions appropriate over two-thirds of their students' Pell Grant aid, potentially suggesting that these schools have more market power than those in other sectors.

Finally, this paper contributes to a broader literature on the effectiveness of targeted subsidies and the importance of considering impacts on the behavior of both consumers and firms (e.g., Rothstein 2008; Hastings and Washington 2010). Previous studies explicitly focusing on the Pell Grant Program find a positive correlation between listed tuition and Pell Grant generosity (e.g., McPherson and Schapiro 1991; Singell and Stone 2007). However, these impacts are identified using time-series variation in the maximum Pell Grant award, variation that is likely correlated with unobservable year specific shocks to the economy. My empirical approach overcomes this limitation taking advantage of variation in Pell Grant aid within a given school and year. As has been shown to be the case in other settings, I find no evidence that Pell Grant aid affects low-income students' college enrollment or the quality of college attended, suggesting that the scope for capture of Pell Grant aid via tuition increases may be limited.[3] Other sources of federal and state financial aid have been shown to crowd out institutional grants by as much as 100 percent (e.g., Long 2004;

[1] Card et al. (2015) show that in the presence of a combined discontinuity and kink and heterogeneous treatment effects, the parameter identified by the RK estimator will not have a causal interpretation. I show that under assumptions over the particular form of heterogeneity in treatment effects, it is possible to use both the RD and RK estimators to identify causal parameters of interest.

[2] See, for instance, Rothschild and White (1995), Hoxby (1997), Winston (1999), Epple, Romano and Sieg (2006), Epple et al. (2013); Cellini and Goldin 2014; Dinerstein et al. (2015); Jacob, McCall and Stange forthcoming.

[3] See, for example, Kane (1995), Rubin (2011), Carruthers and Welch (2015), and Marx and Turner (2015).

Turner 2012; Bettinger and Williams 2015). In contrast, I estimate that on average, Pell Grant recipients receive at least \$0.80 of each Pell Grant dollar.

2 The Pell Grant Program

Established to promote access to postsecondary education, the federal Pell Grant Program is the largest source of need-based student aid in the United States. In 2015, over 8.3 million low-income received Pell Grant subsidies totaling \$30.6 billion (U.S. Department of Education 2016*a*). The maximum Pell Grant has grown in generosity from \$1,400 during the 1975-76 school year (hereafter, 1976) to \$5,775 in 2016, a 1 percent decrease in real terms (Figure 1).[4] Over this period, the purchasing power of the maximum Pell Grant has fallen from 67 percent to 27 percent of the average cost of college attendance.[5]

A student's Pell Grant depends on both the annual maximum award and her expected family contribution (EFC), the federal government's measure of need. Students must complete a Free Application for Federal Student Aid (FAFSA) to qualify for Pell Grants and other sources of federal student aid. The FAFSA requires detailed financial and demographic information, such as income, untaxed benefits, assets, family size and structure, and number of siblings in college. The federal government calculates a student's EFC using a complicated, non-linear function of these inputs.[6] Students specify up to six schools (ten after 2008) they are considering attending. The federal government provides each of these schools with the student's EFC and FAFSA inputs. Schools then calculate the student's eligibility for federal and state grants. With this information in hand, schools choose how to distribute institutional grant aid across students. Thus, a school observes a student's FAFSA, EFC, and outside aid before deciding the level of its own discount from listed tuition. Students receive a financial aid package from each school specifying federal, state, and institutional grant aid and loans. Students do not observe their Pell Grant award until this point, where it is included as a component of the final price (i.e., tuition net of grants from all sources) displayed in their financial aid package.

A full-time, full-year student is eligible for a Pell Grant award equal to:

$$\begin{aligned} Pell_{it} = &\left(maxPell_t - EFC_{it}\right) \mathbf{1}\left[maxPell_t - EFC_{it} \geq minPell_t\right] \\ &+ minPell_t \mathbf{1}\left[maxPell_t - EFC_{it} \in (0, minPell_t)\right] \end{aligned} \tag{1}$$

Where $maxPell_t$ ($minPell_t$) is the maximum (minimum) Pell Grant in year t, EFC_{it} is the expected family

[4] Although Pell Grant aid was first disbursed 1974, the program was fully implemented in 1976.

[5] Appendix Figure C.1 displays the purchasing power of the maximum Pell Grant relative to the average cost of attendance and average tuition and fees between 1976 and 2014.

[6] The Department of Education's 36 page *EFC Formula Guide* provides a detailed explanation of the formula used to calculate a student's EFC (e.g., http://ifap.ed.gov/efcformulaguide/attachments/082511EFCFormulaGuide1213.pdf).

contribution of student i in year t, and $\mathbf{1}[\cdot]$ is the logical indicator function.[7]

The Pell Grant formula generates two sources of variation that I use for identification. First, crossing the Pell Grant eligibility threshold leads to a discrete increase in a student's statutory award, from \$0 to $minPell_t$, which enables me to use a regression discontinuity design . Second, the variation created by the change in the slope of the Pell Grant-EFC function, from 0 to -1, allows me to use a regression kink design.[8]

Students only learn about their Pell Grant after submitting a FAFSA, and this information is provided as part of a school's financial aid package, where the final price – tuition net of state, federal, and institutional grants – is likely the most salient feature. Pell Grant aid may not lead to increased college enrollment if low-income students lack information about their eligibility for aid. Bettinger et al. (2012) show that information and assistance with the FAFSA application process raises the likelihood of college enrollment for low-income students. Most prospective students do not "shop around" for the best price: among Pell eligible and near-eligible students enrolling in college first the first time, only 32 percent listed more than one school on their FAFSA.[9] Perhaps not surprisingly, past research finds no effect of Pell Grant aid on college enrollment or college quality for most students (Kane 1995; Rubin 2011; Carruthers and Welch 2015; Marx and Turner 2015).[10]

The weak response of student demand to Pell Grant aid suggests the potential for schools to appropriate these subsidies by increasing prices. Singell and Stone (2007) find a positive correlation between Pell Grant generosity and private institutions' published tuition. However, these effects are identified using time-series variation in the maximum Pell Grant, which may be correlated with unobservable year specific shocks. Additionally, as Hoxby (1997) argues, few public and nonprofit schools enroll a sufficiently large population of Pell Grant recipients for tuition increases to yield a substantial increase in revenue and many public schools lack control over tuition setting. The for-profit sector represents an exception to both of these arguments. On average, 63 percent of for-profit students received Pell Grants in 2014 and most for-profit schools set

[7] The minimum Pell Grant award was \$400 prior to 2009, and increased to \$890 in 2009, \$976 in 2010, and \$1,176 in 2011, and was lowered to \$555 in 2012. The minimum award for half-time students is the same as that received by full-time students, while the slope of the relationship between Pell Grant aid and EFC is 0.5. Part-year students receive a prorated grant. Pell Grant awards are rounded up to the nearest \$100.

[8] Although eligibility for other forms of federal aid (e.g., subsidized loans, work study) also may depend on a student's EFC, the Pell Grant eligibility threshold does not correspond to changes in eligibility for any other federal programs except for the short-lived Academic Competitiveness Grant (ACG) and National Science and Mathematics Access to Retain Talent (SMART) Grant programs. The ACG program targeted first- and second-year Pell Grant recipients that had completed a rigorous secondary school program with up to \$1,300 in grant aid per year. Third- and fourth-year students enrolled in a qualifying degree program (e.g., STEM fields, critical foreign language studies) were selected by their institution to receive a SMART Grant of up to \$4,000. Funds from these programs were first released in fall of 2006 and discontinued in 2011. Other federal grants include the Supplemental Educational Opportunity Grant (SEOG) and and smaller programs that target specific students or careers (e.g., TEACH Grants for students that intend to become teachers in high-need fields and will work in low-income areas). Schools have discretion over the allocation of SEOG grants as long as funds are directed to students with unmet financial need.

[9] Pell Grant eligibility is uncorrelated with the number of schools listed on students' FAFSAs or with the probability of listing more than one school.

[10] Seftor and Turner (2002) show that the Pell Grant Program's introduction increased enrollment of some non-traditional, older students.

tuition at the program-level.[11] Cellini and Goldin (2014) show that sub-baccalaureate for-profit institutions that are eligible to disburse federal student aid charge 78 percent more for associate's degree and certificate programs than similar schools that do not offer federal aid charge for similar programs. This amount is approximately equal to the value of federal subsidies received by for-profit students.

Raising tuition is only one method schools may use to capture Pell Grant aid. Schools can also adjust students' prices by altering the institutional aid provided to Pell Grant recipients. The practice of price discrimination, or offering a schedule of prices that varies according to consumer demand elasticities (and potentially other attributes), has been documented in a variety of imperfectly competitive markets. The market for higher education is unique in the extensive amount of customer information schools observe before setting prices, including a measure of students' ability to pay. Pell Grant aid is only one component of the price offered to students, making it less salient then the final (tuition net of all grant aid) price.

Long (2004) and Turner (2012) find evidence that schools respond to other sources of financial aid by decreasing institutional grants.[12] Epple et al. (2013) model the impact of federal grant aid increases on enrollment and prices using a general equilibrium model of the market for higher education and predict that reductions in institutional aid would crowd out close to 60 percent of simulated federal aid increases provided to nonprofit students. However, the two studies that explicitly examine whether Pell Grant aid crowds out institutional aid provide conflicting results (McPherson and Schapiro 1991; Li 1999).[13]

3 Data and Descriptive Statistics

I primarily use data from the National Postsecondary Student Aid Study (NPSAS), a nationally representative, restricted-use, repeated cross-section of college students. My sample includes students from the 1996, 2000, 2004, and 2008 NPSAS waves.[14] The NPSAS contains information on each student's EFC,

[11] In 2014, total enrollment in degree-granting for-profit institutions was 2.7 million. Of these students, 1.7 million received Pell Grants (2015 Digest of Education Statistics, Table 308.20, available at: https://nces.ed.gov/programs/digest/d15/tables/dt15_308.20.asp; U.S. Department of Education (2015), Table 5A). In comparison, approximately 29 percent of the 19.6 million students enrolled in degree-granting public schools and 24 percent of the 4.9 million nonprofit students received Pell Grants.

[12] Long (2004) examines the implementation of the Georgia HOPE scholarship program, which provides substantial assistance to students in Georgia who achieve a 3.0 GPA and finds that private nonprofit institutions captured 30 percent of HOPE aid by increasing tuition and fees and reducing institutional aid. Turner (2012) focuses on tax-based aid, which primarily benefits middle class students, and finds that schools reduce institutional aid dollar for dollar with estimated education tax benefits.

[13] Using time-series variation in the maximum Pell Grant award, McPherson and Schapiro (1991) find a positive correlation between Pell Grant generosity and overall institutional aid levels. Li (1999) uses administrative Pell Grant data and a simulated instrumental variables approach, and finds a positive relationship between Pell Grant aid and both listed tuition and per-student net tuition. By comparing the impact of Pell Grant aid on per-student net and listed tuition, she estimates that four-year institutions increase tuition and reduce institutional aid.

[14] I do not use observations from the latest wave of the NPSAS, which includes college students enrolled during the 2011-12 academic year. This is because the 2012 NPSAS sample yields a discontinuous decrease in the number of students enrolled in college at the Pell Grant eligibility threshold, suggesting that Pell Grant eligibility leads to an approximately 25 percent *reduction* in the probability of attending college (e.g., Appendix Figure D.1 and Appendix Table D.1). The decrease in the number of students on the eligible side of the threshold is not due to differential sampling; sample weights are continuous through the threshold. One explanation for the counter-intuitive interpretation that Pell Grant eligibility *reduces* college enrollment

demographic characteristics, FAFSA inputs, and financial aid from all sources. I exclude graduate and first-professional students as well as noncitizens and non-permanent residents from the sample, as these students are ineligible for federal student aid. I exclude students who attended multiple schools in the survey year, received athletic scholarships, and were not enrolled in the fall semester. Finally, I exclude all students attending military academies, schools that only offer sub-associate certificate programs, theological seminaries, and other faith-based institutions, since many of these schools are not eligible to distribute federal aid.[15]

I focus on students with EFCs that are no greater than $4,800 from the Pell Grant eligibility threshold, which is the largest symmetric window around the eligibility threshold. However, my estimates are robust to larger and narrower windows. My main analysis sample includes approximately 104,300 undergraduate students attending 2,200 unique institutions.[16]

I classify schools by selectivity and control, distinguishing between public, nonprofit, and for-profit institutions that are either nonselective or "more selective". To be clear, "more selective" public and nonprofit institutions in my sample largely are not highly selective. Only 2 percent of schools (representing 1 percent of students in my primary sample) are classified by the Barron's Guide as being the most selective, a category that encompasses the set of schools that are traditionally labeled as "selective". I use the Integrated Postsecondary Education Data System (IPEDS) and *Barron's College Guide* to determine an institution's selectivity. The IPEDS contains annual data on acceptance rates and the *Barron's Guide* groups four-year public and nonprofit schools into six categories of selectivity based on acceptance rates, college entrance exam scores, and the minimum class rank and grade point average required for admission. I classify all for-profit schools and institutions offering two-year programs as nonselective. If the IPEDS lists an institution as offering open admissions, I also classify it as nonselective. Finally, I classify remaining institutions as nonselective if either the Barron's Guide lists them as "less competitive" or "non-competitive" or they are missing Barron's Guide rankings and admit over 75 percent of applicants. Appendix B provides additional details on the data and sample construction.

Table 1 displays the characteristics of students in my sample by Pell Grant receipt, illustrating why a naïve comparison of prices charged to recipients and non-recipients would be problematic. Although Pell Grant recipients are more likely to receive institutional aid, they also have lower income, greater need (lower EFC) and are more likely to be non-white.[17]

is changes in the Department of Education's verification procedure that led to a substantial increase in the likelihood of Pell Grant eligible applicants being selected and potentially, a corresponding decrease in the probability of completing the verification process and ultimately enrolling in college. Appendix D provides additional details.

[15] After the original 2008 NPSAS sample was drawn, additional observations of National Science and Mathematics Access to Retain Talent (SMART) Grant recipients were added. For my main set of estimates, I drop oversampled SMART Grant recipients. My results are robust to using the NPSAS sampling weights and retaining SMART Grant recipients or excluding observations from 2008.

[16] All sample sizes are rounded to the nearest 10 per Department of Education requirements.

[17] Appendix Table C.1 reports sample characteristics by Pell Grant receipt and sector.

4 Empirical Framework: RK and RD Designs

I identify the impact of Pell Grant aid on college pricing using variation induced by the kink and the discontinuity in the relationship between Pell Grant and EFC at the threshold for Pell Grant eligibility. The kink occurs where the slope of the Pell Grant schedule changes from 0 to -1, while the discontinuity is driven by the increase from in Pell Grant aid from \$0 to the minimum Pell Grant at the eligibility threshold. This variation allows me to use both a regression discontinuity (Hahn, Todd and der Klauuw 2001; Lee and Lemieux 2010) and a regression kink design (Nielsen, Sørensen and Taber 2010; Card et al. 2015).

Similar to the RD design, the RK design allows for identification of the impact of an endogenous regressor (i.e., Pell Grant aid) that is a known function of an observable assignment variable (i.e., EFC). The RK design uses variation induced by a change in the slope of the relationship between Pell Grant aid and EFC as the eligibility threshold is approached from above and below. Like the RD design, the RK design will be invalidated if individuals are able to sort perfectly in the neighborhood of the kink (Card et al. 2015).

Let $Y = f\left(Pell, \tau\right) + g\left(EFC\right) + U$ represent the causal relationship between institutional aid, Y, and Pell Grant aid, $Pell = pell\left(EFC\right)$, for a given school and year; U is a random vector of unobservable, predetermined characteristics. The key identifying assumptions for inference using the RK design are (1) in the neighborhood of the eligibility threshold, there are no discontinuities in the direct impact of EFC on institutional aid and (2) the conditional density of EFC (with respect to U) is continuously differentiable at the threshold for Pell Grant eligibility (Card et al. 2015). These assumptions encompass those required for identification using a RD design. Essentially, even if many other factors affect college pricing decisions, as long as the relationship between these factors and EFC evolves continuously across the Pell Grant eligibility threshold, RK and RD designs will approximate random assignment in the neighborhood of the kink. Additionally, as with the RD design, the second assumption generates testable predictions concerning how the density of EFC and the distribution of observable characteristics should behave in the neighborhood of the eligibility threshold.

Assume that each additional dollar of Pell Grant aid has the same marginal effect on schools' pricing decisions (in the neighborhood of the eligibility threshold):

$$f\left(Pell, \tau\right) = \tau_1 Pell \tag{2}$$

In this case, τ_1 represents the pass-through of each additional dollar of Pell Grant aid from students to schools. If the required identifying assumptions hold, the RK estimator identifies:

$$\tau_{RK} = \frac{\lim\limits_{\varepsilon \uparrow 0} \left[\frac{\partial Y | EFC = efc^0 + \varepsilon}{\partial efc} \right] - \lim\limits_{\varepsilon \downarrow 0} \left[\frac{\partial Y | EFC = efc^0 + \varepsilon}{\partial efc} \right]}{\lim\limits_{\varepsilon \uparrow 0} \left[\frac{\partial Pell | EFC = efc^0 + \varepsilon}{\partial efc} \right] - \lim\limits_{\varepsilon \downarrow 0} \left[\frac{\partial Pell | EFC = efc^0 + \varepsilon}{\partial efc} \right]} = \tau_1 \tag{3}$$

Where efc^0 represents value of EFC at the eligibility threshold. Since the Pell Grant Program's schedule also contains a discontinuity in the level of aid, I can also identify the impact of Pell Grant aid on college pricing decisions using an RD design:

$$\tau_{RD} = \frac{\lim\limits_{\varepsilon \uparrow 0} \left[Y | EFC = efc^0 + \varepsilon \right] - \lim\limits_{\varepsilon \downarrow 0} \left[Y | EFC = efc^0 + \varepsilon \right]}{\lim\limits_{\varepsilon \uparrow 0} \left[Pell | EFC = efc^0 + \varepsilon \right] - \lim\limits_{\varepsilon \downarrow 0} \left[Pell | EFC = efc^0 + \varepsilon \right]} = \tau_1 \tag{4}$$

In practice, my estimation strategy involves "fuzzy" RD/RK. Some students do not apply for federal aid and thus, do not receive Pell Grants.[18] Students with less than full-time enrollment face a lower eligibility threshold. Finally, students who leave school after one semester will only receive a prorated Pell Grant.

Since the location of the Pell Grant eligibility threshold changes as the maximum award increases, I create a standardized measure of the distance of a student's EFC from the year-specific eligibility threshold: $\widetilde{EFC}_{it} = EFC_{it} - efc^0_t$, where efc^0_t is the cut-off for Pell Grant eligibility in year t for student i and all students with $\widetilde{EFC}_{it} \geq 0$ are ineligible for Pell Grant aid. Figure 2 displays the empirical distribution of Pell Grant aid for students in my sample by standardized EFC.[19]

Consider the following first stage and reduced form equations:

$$Pell_{it} = \eta \mathbf{1} \left[\widetilde{EFC}_{it} < 0 \right] + \delta \widetilde{EFC}_{it} \mathbf{1} \left[\widetilde{EFC}_{it} < 0 \right] + \psi_t \widetilde{EFC}_{it} + \theta_{jt} + \nu_{ijt} \tag{5}$$

$$Y_{ijt} = \beta \mathbf{1} \left[\widetilde{EFC}_{it} < 0 \right] + \gamma \widetilde{EFC}_{it} \mathbf{1} \left[\widetilde{EFC}_{it} < 0 \right] + \lambda_t \widetilde{EFC}_{it} + \xi_{jt} + \epsilon_{ijt} \tag{6}$$

Where $Pell_{it}$ is the Pell Grant received by student i in year t and Y_{ijt} represents institutional grant aid provided by school j. The term $\mathbf{1} \left[\widetilde{EFC}_{it} < 0 \right]$ indicates Pell Grant eligibility and θ_{jt} and ξ_{jt} represent school by year fixed effects. My main specification includes a linear term in $\widetilde{EFC}$.[20] Since my data spans the 12 year period between 1996 and 2008, I allow the effect of $\widetilde{EFC}$ to vary by survey year.[21] The ratio of

[18] For such students, the NPSAS approximates their EFC using a combination of administrative and survey data.

[19] The kink and discontinuity in the relationship between Pell Grant aid and EFC occur at slightly different values of EFC (e.g., Appendix Figure C.2). However, the distance between these points is quite small and only a small fraction of students have an EFC placing them at this "plateau". I treat both the slope and the level of Pell Grant funding changes as occurring at the eligibility cut-off. My results are robust to removing students whose EFC falls on the plateau (forcing the discontinuity and kink to occur at the same value of EFC).

[20] This is the degree of polynomial that minimizes the Akaike Information Criterion (AIC) and and avoids bias that may caused by the inclusion of higher order polynomials (Gelman and Imbens 2014).

[21] My estimates are robust to the inclusion of a vector of predetermined student characteristics, including indicators for gender, race, dependency status, level (e.g., whether the student is a first year, second year, etc.), out-of-state student, and a quadratic

the reduced form and first-stage coefficients for the interaction between $\mathbf{1}\left[\widetilde{EFC}_{it} < 0\right]$ and the linear term in $\widetilde{EFC}_{it}$, $\hat{\tau}_{RK} = \frac{\hat{\gamma}}{\hat{\delta}}$, represents the RK estimate of the impact of Pell Grant aid on institutional aid. Likewise, the ratio of the reduced form and first-stage coefficients for Pell Grant eligibility, $\hat{\tau}_{RD} = \frac{\hat{\beta}}{\hat{\eta}}$, represents the RD estimate of the impact of Pell Grant aid on institutional aid.

4.1 Evaluating the RD and RK identifying assumptions

Identification with RD and RK designs hinges on the assumption that students and their families lack complete control over their EFCs. Students and their parents likely act to increase their estimated need, but as long as they cannot chose an exact value of EFC, the RK and RD estimators will be consistent (Lee 2008). Although online calculators and guides can help families predict their potential EFC, these guides are based on prior year Pell Grant schedules. In the years I examine, the maximum Pell Grant awards are set by amendments to the Higher Education Act (HEA). However, the HEA amendments only specify authorized annual maximum awards. The appropriated maximum award, which determines the actual Pell Grant schedule, is generally smaller than the authorized amount. Moreover, in most years, the Department of Education releases the Pell Grant schedule after the end of calendar year, making it impossible for families to make real adjustments to most of the inputs used to determine EFC (e.g., adjusted gross income).

Families might still misreport EFC inputs after the end of the calendar year but many of these inputs are also reported to the IRS and over one-third of all FAFSA applications are audited through the Department of Education's verification process. The NPSAS contains an additional year of FAFSA information for continuing students who reapply for federal aid, allowing me to test for evidence of strategic behavior by examining whether a given student's $\widetilde{EFC}$ in year $t+1$ is continuous and smooth at the Pell Grant eligibility threshold in year t. I find no evidence of EFC manipulation for students who fell just above the eligibility threshold in the prior year (Appendix Figure C.3).[22]

I also formally test the continuity and smoothness of the distribution of students at the Pell Grant eligibility threshold. Figure 3 displays the unconditional density of $\widetilde{EFC}$, plotting the proportion of students in each \$200 $\widetilde{EFC}$ bin, up to \$10,000 above the Pell Grant eligibility threshold. This window is larger than that used for empirical estimates for expositional purposes. To test for discontinuities in the level and slope of the density of $\widetilde{EFC}$ at the Pell Grant eligibility threshold, I collapse the data into \$200 $\widetilde{EFC}$ bins, and

in student age.

[22] I also examine the density of observations that submit a FAFSA in year t and $t+1$ by distance to the Pell Grant eligibility threshold, to determine if receiving a Pell Grant increases the probability a given student will reapply for student aid in the following year, and find no evidence of a discontinuity in the level or slope of the density (results available upon request).

estimate:

$$N_b = \alpha + \beta \mathbf{1}\left[\widetilde{EFC}_b < 0\right] + \sum_{\rho}\left[\gamma_\rho \left(\widetilde{EFC}_b\right)^{\rho} \mathbf{1}\left[\widetilde{EFC}_b < 0\right] + \pi_\rho \left(\widetilde{EFC}_b\right)^{\rho}\right] + \epsilon_b \tag{7}$$

Where N_b represents the number of students in bin b, students with an $\widetilde{EFC}$ more than \$4,800 above the eligibility threshold excluded, and $\rho = 10$ is chosen to minimize the AIC.[23] I find no evidence that the level or the slope of the density change discontinuously at the eligibility threshold; with $\hat{\beta} = 16\,(52)$, $\hat{\gamma}_1 = 5.897\,(10.904)$, and $p = 0.188$ from an F-test of joint equality.[24]

Finally, I examine the distribution of predetermined student characteristics around the eligibility threshold, including race, gender, dependency status, average SAT score (first-year students only), age, and adjusted gross income (AGI). Figure 4 displays recentered residuals from a regression on school by year fixed effects, where bins again represent \$200 $\widetilde{EFC}$ intervals. To formally test for discontinuous changes in the slope and level of these characteristics at the Pell Grant eligibility threshold, I estimate a version of equation (6) that includes institution by year fixed effects, class level fixed effects, and a polynomial in $\widetilde{EFC}$, allowed to vary on either side of the Pell Grant eligibility threshold (choosing the degree of polynomial to minimizes the AIC). Appendix Table C.2 contains these results (estimated separately for new entrants versus returning students). Among returning students, none of the estimates are statistically significant. Among first-time, first-year students, I find no evidence of significant changes in the level of these predetermined characteristics at the Pell Grant eligibility threshold, and only one of the six estimates of the change in slope are significant. The magnitude of the change in the slope of the relationship between $\widetilde{EFC}$ and age is quite small, albeit statistically significant with $p < 0.01$. The estimate implies that moving from eligibility threshold to -1000 below the threshold (which corresponds to an approximately \$800 increase in Pell Grant aid) is correlated with an increase in average age of 0.1 years.

5 Results

Figure 5 previews my main results. I pool observations from all schools across years and plot the relationship between $\widetilde{EFC}$, Pell Grant aid, and institutional grant aid. The latter two variables are recentered residuals from a regression on school by year fixed effects so that differences in amounts across the $\widetilde{EFC}$ distribution

[23] Figure (3) excludes students with a zero EFC for the purpose of exposition, but I include these observations when estimating equation (7). In the years I examine, dependent students and independent students with dependents other than a spouse received an automatic zero EFC if (1) anyone in their household receive means tested benefits or their household was not required to file IRS Form 1040, and (2) their household adjusted gross income was below a set threshold (\$12,000 in 1996, \$13,000 in 2000, \$15,000 in 2004, and \$20,000 in 2008,).

[24] Smaller and larger bin sizes yield similar estimates (in percentage terms) of $\hat{\beta}$ and $\hat{\gamma}$. I find no evidence of discontinuities in the levels or slopes of density functions that are estimated separately by year (Appendix Figure D.2) or year and sector (Appendix Figures D.3 through D.7).

represent within school-year differences. Each marker represents average institutional aid or average Pell Grant aid by distance from the threshold for Pell Grant eligibility within a given \$200 $\widetilde{EFC}$ bin. Institutional aid is represented by hollow circles, with larger circles representing a greater number of students in the bin. Average Pell Grant aid is represented by the gray "X" markers. The black lines represent the linear fit of institutional aid on $\widetilde{EFC}$, estimated separately on either side of the eligibility threshold and weighted by the number of students in the bin. The dashed gray lines represent the 95 percent confidence intervals for these estimates. Finally, the diagonal dashed black line represents the linear fit of Pell Grant aid on $\widetilde{EFC}$. For expositional purposes, I use a window around the Pell Grant eligibility threshold that is approximately twice as large as the window used to generate point estimates.

For Pell Grant-ineligible students, institutional aid is increasing in need (decreasing in EFC). At the eligibility threshold, both the relationship between $\widetilde{EFC}$ and institutional grant aid and the level of institutional grant aid changes discontinuously. For eligible students, institutional aid is decreasing in need, while institutional aid is increasing in need for ineligibles. However, barely eligible students also experience a net increase in institutional aid. As shown in Appendix Figure C.4, the relationship between institutional grant aid and $\widetilde{EFC}$ remains approximately linear over the full support of the running variable.

I replicate this exercise by sector (Figure 6). Due to sample size constraints, I pool selective and nonselective public schools into a single category and likewise group nonselective nonprofit and for-profit schools; bins represent \$250 $\widetilde{EFC}$ intervals. In all cases, the relationship between institutional grant aid and $\widetilde{EFC}$ changes discontinuously at the eligibility threshold, although the magnitude of this response varies considerably across sectors. However, the change in the level of institutional grant aid at the eligibility threshold is not consistent across sectors. Public institutions appear to supplement Pell Grants with increased institutional grant aid (Panel A). There is no evidence of this type of response among nonselective private institutions (Panel B). Finally, there is a small, insignificant jump in institutional aid for students attending selective nonprofit schools.

5.1 Impacts of Pell Grant eligibility and generosity on institutional aid

Table 2 presents OLS and IV estimates of equations (5) and (6), focusing on students within the symmetric \$4,800 $\widetilde{EFC}$ window around the Pell Grant eligibility threshold. The first two columns display the first stage and reduced form estimates, respectively. Estimates from equation (5), suggests that Pell Grant eligibility leads to a \$189 increase in Pell Grant aid and, for every dollar increase in need (decrease in EFC), eligible students experience a \$0.62 increase in Pell Grant aid. Estimates from (6) suggest that Pell Grant eligibility leads to a \$108 increase in institutional grant aid, but with every dollar increase in need (decrease in EFC), eligible students experience a \$0.12 reduction in institutional grants.

Columns 3 and 4 present RK and RD instrumental variables estimates, which are consistent with Figure 5. On average, institutions capture 19 cents of every Pell Grant dollar provided to students near the eligibility threshold through reductions in institutional aid. Conversely, the IV-RD estimator results in a point estimate of 0.57, suggesting schools increase institutional aid by close to 60 cents for every dollar of Pell Grant aid received by students near the eligibility threshold. The test of equality of the RD and RK coefficients confirms that the difference in coefficients is statistically significant ($p = 0.005$).[25]

5.2 Robustness and Placebo Tests

These results are robust to a variety of different specifications and sample limitations. First, I estimate local linear regression models with a rectangular kernel and the bandwidth chosen following Imbens and Kalyanaraman (2012) (IK), the Fan and Gijbels (1996) (FG) rule of thumb (Panel B), or Calonico, Cattaneo and Titiunik (2014) (CCT). I use the bandwidths chosen in the reduced form models when estimating IV models. As shown in Table 3, IV-RK estimates are negative, statistically significant, and for the IK and FG bandwidths, quite similar in magnitude to the results from my main specification, suggesting that, on average, institutions reduce their own grant aid by \$0.20 for every dollar of Pell Grant aid. The substantially smaller CCT bandwidth produces a point estimate that is larger in magnitude (-0.48) and much less precise than the estimates obtained from using larger bandwidths.[26] IV-RD estimates positive but much less precise, suggesting that, on average, institutions increase grant aid by \$0.46 to \$0.68 for every dollar of Pell Grant aid. The test of the equality of IV-RD and IV-RK coefficients can be rejected with $p < 0.05$ for models that use the IK and FG bandwidths, but is not significant at conventional levels when the CCT bandwidth restriction is employed.[27]

Table 4 presents results from additional robustness tests. To account for the possibility that estimated crowd out is affected by changes in other funding sources at the Pell Grant eligibility, the models in Panel A replace Pell Grant aid with the sum of Pell, state, and other federal grant aid.[28] IV-RD and IV-RK

[25] Appendix Table C.3 presents results from models that allow for heterogeneous impacts of Pell Grant aid by sector. IV-RD point estimates are positive across all sectors except for-profits, but only statistically significant in the selective public sector. IV-RK point estimates are negative and statistically significant (except for nonselective nonprofits), ranging from -0.09 (nonselective publics) to -0.88 (more selective nonprofits).

[26] CCT bandwidths chosen when regularization term is excluded (3060 in the case of the RK estimator and 5419 in the case of the RD estimator) are much closer to the IK and FG bandwidths.

[27] Appendix Figure C.5 displays the estimated kink and discontinuity from first stage and reduced form models with bandwidths between 200 and 30,000.

[28] Bettinger and Williams (2015) examine the interaction between state and federal grant aid, and show that in Ohio, increases in Pell Grant generosity were met with decreases in state grant aid for students with the greatest need. In some states, institutions receive a pot of funding from state grant aid programs that can be distributed across a broad set of students (e.g., those with any unmet need) at the discretion of institutions. In these cases, state grant aid should arguably be combined with institutional grant aid rather than federal grant aid. Thus, the Panel A models generate a conservative estimate of whether state-level policies can explain the relationship between Pell Grant aid and institutional grant provision. As shown in Appendix Figure C.6, there is no visible relationship between $\widetilde{EFC}$ and average state grant aid at the Pell Grant eligibility threshold.

estimates from this model are largely consistent with my main results, suggesting that a dollar of Pell Grant aid leads to a 0.19 decrease in institutional aid, in the case of the IV-RK, and a 0.29 increase in institutional aid in the case of the IV-RD. Panel B models exclude students enrolled in schools that have pledged to meet "full need" in the study year. Since students in these schools will have no unmet need, increases in Pell Grant aid will lead to a mechanical decrease in institutional aid.[29] Only 700 students in my sample attend such institutions. In this restricted sample, point estimates are very close to those produced using the main sample. Panel C reports results from models in which institutions that never provide institutional aid over the sample period are dropped. Approximately 10,230 students (10 percent of the sample) attend such institutions. Point estimates slightly larger than those reported in Table 2: the RK estimate indicates that a dollar of Pell Grant aid lowers institutional grant aid by 21 cents and the RD estimate showing that schools increase institutional grants by 60 cents for ever dollar of Pell Grant aid..

The Panel D model, which weights observations by the NPSAS sampling weights, results in an IV-RK point estimate of 0.16 and an IV-RD point estimate of 0.35, with the latter being insignificant at conventional levels.[30] Finally, Panels E and F contain estimates from models that include controls for predetermined student characteristics and exclude school by year fixed effects, respectively. Including covariates does substantially affect the magnitude of the point estimates. Excluding institution by year fixed effects leads to an increase in both standard errors and the magnitude of both RK and RD estimates (to -0.42 and 1.77, respectively), suggesting that school-year specific effects account for substantial heterogeneity in institutional responses to Pell Grant aid.

Table 5 summarizes the impact of Pell Grant aid on total grant aid and students' effective prices. First, I examine the effect of Pell Grant aid on total grant aid received from all federal, state, and institutional sources (Panel A). If Pell Grant aid receipt did not affect receipt of other grants, this coefficient would mechanically be equal to 1. Instead, the RK estimate is significantly less than 1 (0.80) and the RD estimate significantly exceeds 1 (2.76).[31] Panel B displays estimated effects of Pell Grant aid on students' effective prices (tuition minus institutional grant aid). If all students paid the same tuition, these estimates would mechanically be equal to the estimated effects of Pell Grant aid on institutional grants multiplied by -1.

[29] The Project on Student Debt provides a list of schools that have pledged to meet full need and the corresponding pledge details (available at: http://projectonstudentdebt.org/pc_institution.php). In 2008, less than 2 percent of all Pell Grant recipients (representing 2 percent of Pell Grant expenditures) attended schools that had an ongoing pledge relating to meeting need (calculations using Pell Grant administrative data, available upon request). Many of these schools only guaranteed full need being met for a subset of students, such as those with a zero EFC (e.g., University of Illinois at Urbana-Champaign, University of Maryland at College Park, and University of Michigan) while others met need using loans and work-study (e.g., Brown University, University of Virginia, Rice University, and others).

[30] With heteroskedastic standard errors, weighting can reduce precision since NPSAS sampling of students within institutions is independent of Pell Grant eligibility within a given wave (Solon, Haider and Wooldridge 2015).

[31] The fact that this point estimate is substantially larger in magnitude than the estimated effect of Pell Grant aid on institutional grants suggests that schools have access to other federal and state grants can be distributed at the discretion of the institution. The federal supplemental education opportunity grant (SEOG) is one such example.

However, in some institutions, tuition varies across programs or with the number of credits attempted. The IV-RK estimate suggests that each dollar of Pell Grant aid leads to a \$0.21 increase in students' effective prices, which is quite similar to the conclusion reached when examining impacts on institutional grant aid. Likewise, the IV-RD point estimate suggests that each dollar of Pell Grant aid leads to a \$0.64 decrease in effective prices, a larger but qualitatively similar effect to that obtained from my main specification. Finally, I examine the effect of Pell Grant aid on students' final prices (tuition net of grant aid from all sources) in Panel C. The RK estimate suggests that students' final prices fall by \$0.78 for every dollar of Pell Grant aid received, significantly less in magnitude than the mechanical effect of Pell Grant aid on prices. The RD estimate suggests that every dollar of Pell Grant aid leads to a \$2.87 reduction in final prices, significantly larger in magnitude than the mechanical effect of Pell Grant aid alone.

Finally, I perform the permutation test proposed by Ganong and Jäger (2014) by estimating placebo regressions using observations away from the actual Pell Grant eligibility threshold. To do so, I draw 500 placebo thresholds uniformly distributed over $\widetilde{EFC} \in [8798, 100000]$, with the lower bound representing 200 percent of the Fan and Gijbels (1996) rule of thumb bandwidth that is chosen at the true eligibility threshold.[32] For each placebo threshold, I calculate the Fan and Gijbels (1996) rule of thumb bandwidth and run local linear regressions of institutional grant aid on the running variable and school by year fixed effects, and retain the estimated change in the level and slope of institutional grant aid. Appendix Figure C.7 displays the cumulative distribution of these estimates. Approximately 5 percent of the placebo kink estimates are larger than the estimated kink at actual Pell Grant eligibility threshold, suggesting that while asymptotic standard errors in Table 2 may be slightly overstated, the change in the relationship between institutional grant aid and EFC at the Pell Grant eligibility threshold is larger than what would generally arise from general nonlinearities in this relationship.[33]

6 A Framework for Reconciling RK and RD Estimates

Would a profit-maximizing firm ever pass-through more than 100 percent of a subsidy to consumers? When firms have market power, the economic incidence of a tax or subsidy may exceed 100 percent, but a simple model suggests that opposite signed IV-RD and IV-RK estimates would not occur without very specific patterns of student demand or a departure from pure profit-maximization. First, suppose a profit-maximizing

[32]Only 0.4 percent of NPSAS observations have an $\widetilde{EFC}$ above \$100,000 and the following results are robust to using higher or lower upper bounds for the distribution of placebo thresholds.

[33]However, 30 percent of placebo discontinuity estimates are larger than estimated discontinuity at actual threshold.

monopolist serving N distinct student groups solves:

$$\max_{p_1,\ldots,p_N} \pi = \sum_{i=1}^{N} Q_i\left(p_i\right)\left(p_i - c\right)$$

Where Q_i is the demand function for students in group i and c is the school's marginal cost of serving an additional student. For simplicity, I assume marginal costs are constant, both in the number of students served and across student groups, which is reasonable if instruction and facilities make up the majority of expenses. The school charges students in group i a price that is equal to overall tuition (which does not vary across groups) minus institutional aid (which may vary across groups). Groups are defined by students' observable characteristics (e.g., demographic characteristics, EFC), and schools use these characteristics to practice price discrimination. This is a static problem, where a school's behavior in the current period does not affect cost or demand in future periods.[34]

A profit-maximizing monopolist charges group i students price $p_i = c\mu_i$, where $\mu_i = \left(\frac{e_i}{e_i+1}\right)$ and e_i is the price elasticity of demand of group i students. When federal need-based grant aid, s_i, is introduced, the school charges $p_i = \left(c - s_i\right)\mu_i$, where $s_i < c\ \forall i$. The change in the final price faced by group i students is:

$$\frac{dp_i}{ds_i} = -\mu_i + \left(c - s_i\right)\frac{d\mu_i}{ds_i} \tag{8}$$

If schools fully capture every additional dollar of the subsidy, $\frac{dp_i}{ds_i} = 0$, while $\frac{dp_i}{ds_i} = -1$ indicates that the subsidy is fully passed-through to students. The price set by a school has two components: tuition and institutional aid: $p_i = t - a_i$. Assume that student groups can be ordered in accordance to their effective prices (which depend on demand elasticities and Pell Grant awards), with students in the first group being assigned the highest price. To the extent that schools serve at least some students who are not eligible for Pell Grant aid, and demand elasticities do not vary substantially between Pell eligible and ineligible students, students in the first group will not be eligible for Pell Grant aid. In the absence of administrative costs associated with price discrimination, the monopolist would set tuition of the first group such that $t = c\mu_1 = p_1$ and choose a schedule of discounts $a_2, a_3, \ldots$ such that $p_i = \left(c - s_i\right)\mu_i = t - a_i$. In this case, a marginal increase in Pell Grant aid would only affect student prices vis-a-vis the schedule of institutional discounts: $\frac{dp_i}{ds_i} = -\frac{da_i}{ds_i}$.

The sign of $\frac{dp_i}{ds_i}$ depends on both the elasticity and the curvature of student demand (Bulow and Pfleiderer 1983). If demand is log-concave, $\frac{dp_i}{ds_i} > -1$ and schools capture a portion of students' Pell Grant aid

[34] Additionally, this model assumes that either schools do not face capacity constraints or that capacity constraints are not binding. However, allowing for a binding capacity constraint would only increase pass-through of Pell Grant aid and cannot explain the crowd in implied by IV-RD estimates.

by increasing prices (decreasing institutional aid), the result suggested by the RK estimator. If demand is log-convex, $\frac{dp_i}{ds_i} < -1$, and schools respond to Pell Grant aid by decreasing effective prices (increasing institutional aid), the result suggested by the RD estimator.[35] However, my estimates are not consistent with either cases. With log-convex student demand, institutional transfers should increase as Pell Grant aid increases, suggesting that we would observe a positive relationship between need and institutional aid for Pell Grant eligible students. There would have to be sharp changes in the demand functions of students near the eligibility threshold to account for the patterns of institutional aid provision I observe. Specifically, the minimum Pell Grant award would have to move students from a log-concave portion of their demand curve to a log-convex portion, requiring the existence of an inflection point in log demand. This is unlikely, since while the eligibility threshold for Pell Grant aid changes over time, while pricing patterns are largely persistent over NPSAS years (Appendix Table C.4).

Instead, suppose a subset of schools have a different objective function, and maximize weighted student enrollment, where weights vary across groups:

$$\max_{p_1,\ldots,p_N} W = \sum_{i=1}^{N} \alpha_i Q_i\left(p_i\right) \quad \text{s.t.} \quad \sum_{i=1}^{N} Q_i\left(p_i\right)\left(p_i - c\right) \geq 0$$

The constraint stems from the requirement that in a static model, expenditures cannot exceed revenue. If the constraint is binding, schools will offer a schedule of prices that vary according to students' demand elasticity, the weight placed on the group in the school's objective function (α_i), and the marginal "utility" of revenue (represented by the Lagrange multiplier): $p_i = \left(c - \tilde{\alpha}_i\right)\mu_i$, where $\tilde{\alpha}_i$ is the weight placed on students in group i divided by the Lagrange multiplier.[36] If being labeled as a Pell Grant recipient affects a student's weight in the school's objective function, the school' pricing response to subsidy s_i is now:

$$\frac{dp_i}{ds_i} = -\left(\frac{d\tilde{\alpha}_i}{ds_i} + 1\right)\mu_i + \left(c - \tilde{\alpha}_i\left(s_i\right) - s_i\right)\frac{d\mu_i}{ds_i} \tag{9}$$

Comparing equation (9) to equation (8) suggests that if Pell Grant recipients receive a positive weight in the school's objective function (i.e., $\tilde{\alpha}_i\left(s_i\right) > 0$), the second term will be smaller than in the case of static profit maximization. Furthermore, if Pell Grant recipients' weights are larger than those of observationally

[35] This model can be generalized to represent institutional pricing with monopolistically competitive firms offering differentiated products over the short-run. In this case, student demand will depend not only on an institution's price but the prices offered by competitors, $Q_i = Q_i\left(p_i, p_{-i}\right)$, and pricing will also depend on the cross-price elasticities of demand. Pass-through will be decreasing in the number of competitors in the market and the degree of substitutability between programs offered by institutions. In the long-run, incidence will depend on the ease of entry into a specific market. A substantial minority of institutions are monopolists. In 2012, 12 percent of all institutions eligible to disburse federal aid were the only institution in their county (calculations using Department of Education data on Pell Grant disbursements).

[36] This general framework, in which schools maximize weighted student enrollment, is consistent with Rothschild and White (1995), where weights depend on students' contributions to the education production function, Epple, Romano and Sieg (2006), in which institutions choose prices to maximize "quality" (student income and ability), and Steinberg and Weisbrod (2005), where a nonprofit firm produces a merit good and chooses a schedule of prices for its customers to maximize consumer surplus.

similar students who do not qualify for Pell Grant aid (e.g., $\frac{\tilde{\alpha}_i(s_i)}{ds_i} > 0$), the first term will be larger. If either of these terms is positive, these schools will capture a smaller portion of Pell Grant aid relative to profit maximizing schools. Furthermore, rearranging equation (9) yields:

$$\frac{dp_i}{ds_i} = \left\{-\mu_i + (c - s_i)\frac{d\mu_i}{ds_i}\right\} - \left\{\mu_i\frac{d\tilde{\alpha}_i}{ds_i} + \tilde{\alpha}_i(s_i)\frac{d\mu_i}{ds_i}\right\} \tag{10}$$

Here the first term is equivalent to equation (8), and represents the pass-through of outside student aid due to profit maximization (cost minimization). The second term represents the school's willingness to pay for Pell Grant recipients. If, in the neighborhood of the cut-off for Pell Grant eligibility, $\frac{d\tilde{\alpha}_i}{ds_i}$ does not vary with s for Pell Grant recipients (i.e., if being a Pell Grant recipient increases a student's weight in the school's objective function by a constant amount), the relationship between the prices and Pell Grant aid can be approximated by: $p_i = \tau_0\mathbf{1}[s_i > 0] + \tau_1 s_i + u_i$. Here, τ_0 and τ_1 represent willingness to pay for Pell Grant recipients and the pass-through of each additional dollar of Pell Grant aid, and u_i is an idiosyncratic error term.

Schools might value Pell Grant recipients differently than other students for a number of reasons. First, many schools likely have objectives beyond profit maximization, such as increasing school-wide diversity or maximizing (weighted) student welfare. It may be costly for schools to implement complicated pricing schedules and financial aid offices might instead treat Pell Grant receipt as a proxy for unmet need. Schools might solve a dynamic problem where additional Pell Grant recipients in the current period increase the expected value of the stream of future revenue. For example, schools that serve or graduate a larger number of Pell Grant recipients might receive more funding from state legislatures in the long-run or experience an increase in student demand.[37] For the purposes of this paper, I remain agnostic as to the reasons schools might differentially weight Pell Grant recipient enrollment in their objective functions.

6.1 Treatment dimension estimation

Equation (10) suggests that the "treatment" of receiving a Pell Grant affects prices through two dimensions: a school's willingness to pay for Pell Grant recipients (τ_0) and ability to appropriate outside aid due to the pass-through of cost decreases (τ_1). To see how these two dimensions are related to RD and RK estimates,

[37] The attention paid to the extent to which institutions serve Pell Grant recipients has increased substantially over time. A 2003 Century Foundation issue brief by Donald E. Heller provided information on the share of students that were Pell Grant recipients in highly selective nonprofit and public institutions. In 2008, the U.S. News and World Report began incorporating a measure of Pell Grant receipt in its school ranking calculations (Heller 2003). Beginning in 2015, the Department of Education's College Scorecard measured "low-income students' access to education based on the share of Pell Grant students that the institution enrolls," (source: https://collegescorecard.ed.gov/assets/BetterInformationForBetterCollegeChoiceAndInstitutionalPerformance.pdf) and the Department has ranked institutions based on Pell Grant recipients' graduation rates and post-college earnings (e.g., U.S. Department of Education 2016*b*). Even if Pell Grant aid does not affect college enrollment, schools might still be willing to provide additional grant aid to Pell Grant recipients if schools' objectives include increasing Pell Grant recipients' attainment.

consider a simplified version of equation (6), the reduced form impact of Pell Grant eligibility on institutional aid for students in a specific school and year:

$$y_i = \beta \mathbf{1}\left[\widetilde{EFC}_i < 0\right] + \gamma \widetilde{EFC}_i \mathbf{1}\left[\widetilde{EFC}_i < 0\right] + \lambda \widetilde{EFC}_i + \epsilon_i$$

Furthermore, assume that all eligible students receive a Pell Grant and $pell\left(efc_0\right)$ represents the minimum Pell Grant. Then, the RD design will produce a reduced form estimate of the "treatment" of Pell Grant receipt, with $\beta = \tau_0 + \tau_1 pell\left(efc_0\right)$ and $\tau_{RD} = \frac{\tau_0}{pell(efc_0)} + \tau_1$, and will confound the school's ability to capture an additional dollar of outside aid with its willingness to pay for students labeled as Pell Grant recipients. When these two dimensions have opposite signs, RD estimates will not identify the magnitude *or* the sign of either dimension.

Conversely, the RK design will consistently estimate the pass-through of an additional dollar of outside aid, under the assumption that τ_0 is constant in the neighborhood of the cut-off for Pell Grant eligibility. Since $\tau_{RK} = \tau_1$:

$$\begin{aligned} \hat{\tau}_1 &= \hat{\tau}_{RK} \\ \hat{\tau}_0 &= \left(\hat{\tau}_{RD} - \hat{\tau}_{RK}\right) pell\left(efc_0\right) \end{aligned} \tag{11}$$

Where $\hat{\tau}_{RD}$ and $\hat{\tau}_{RK}$ are the RD and RK estimators, respectively, $\hat{\tau}_0$ is the estimated willingness to pay for Pell Grant recipients, and $\hat{\tau}_1$ is the estimated pass-through of Pell Grant aid from students to schools.[38]

Table 6 presents estimates of pass-through and willingness to pay for the pooled sample (Panel A) and by sector (Panel B) via equation (11). To do so, I jointly estimate equations (5) and (6) and calculate standard errors using the delta method. When examining heterogeneity in treatment dimensions across sectors, all functions of $\widetilde{EFC}$ are allowed to vary by sector.

I estimate that schools' willingness to pay for Pell Grant recipients results in a \$375 increase in institutional grant aid. Since nonrecipients received \$1,433 in institutional grant aid on average, this transfer represents an 26 percent increase in the expected value of institutional aid. Estimated pass-through is -0.19, implying that students' effective prices fall by 81 cents for a given dollar of Pell Grant aid. Thus, only Pell Grant recipients near the eligibility threshold experience a net increase in institutional aid; such students make up only 31 percent of all recipients. The average "switching point" – where Pell Grant recipients would expect to shift from experiencing a net increase in institutional aid to a net decrease – corresponds to a Pell Grant that is approximately \$1970, where average AGI is approximately \$25,000. For the remainder of Pell Grant recipients, schools' ability to capture Pell Grant aid outweighs willingness to pay.

To illustrate that these findings are consistent across a large range of bandwidths, the first two panels

[38] Appendix A provides further details on the derivation of these parameters in both the general case of a multidimensional treatment and the specific case of the Pell Grant Program.

of Figure 7 display estimated pass-through and willingness to pay, as well as corresponding 95 percent confidence intervals, over most of the range of the running variable.[39] The estimates of these parameters are quite stable for bandwidths of $4,000 and above. However, treatment parameter estimates grow noisier at smaller bandwidths, likely due to a declining share of institutions that are represented within smaller bandwidths (7, Panel C). While approximately 98 percent of NPSAS institution by year observations fall within a $4,000 bandwidth, 95 percent are represented in a bandwidth of $3,000, and only 89 percent are represented in a bandwidth of $2,000. Furthermore, declines in representation are uneven across sectors (7, Panel D).[40] To the extent that pass-through and willingness to pay vary by sector, estimates of average pass-through and willingness to pay will only be obtained with accurate representation of institutional sectors in the larger bandwidths.

Panel B of Table 6 documents substantial heterogeneity in pass-through and willingness-to-pay across sectors. Nonselective institutions do not demonstrate a willingness to pay for Pell Grant recipients. In contrast, selective public and nonprofit schools increase institutional aid for recipients by $483 and $1,170, respectively, representing a 64 percent increase in the expected value of institutional grants received by students in public institutions and a 16 percent increase for selective nonprofit students.

Public schools appropriate 5 to 12 cents of every Pell Grant dollar.[41] Among nonselective nonprofit institutions, 8 cents of every Pell Grant dollar is passed-through to schools via reductions in institutional aid. Pass-through in the for-profit sector is 9 cents of every Pell Grant dollar. Pass-through is largest among selective nonprofit institutions: these schools capture 93 cents every Pell Grant dollar. This result suggests that selective nonprofits either serve students with less elastic demand or have greater market power.[42] Due to the high rate of pass-through, very few Pell Grant recipients attending more selective nonprofit institutions receive a net increase in institutional grant aid. The switching point at which pass-through outweighs willingness to pay in this sector corresponds to a Pell Grant of approximately $1,300, corresponding to an average AGI of approximately $30,000.

[39]Estimates from models with bandwidths larger than $30,000 are quite similar to those from models with bandwidths between $10,000 and $30,000 (available upon request).

[40]For example, within a bandwidth of $4,000, over 95 percent of institutions within every sector are represented, while within a $2,000 bandwidth, 91 percent of nonselective public institutions, 97 percent of more selective public schools, 85 percent of nonselective nonprofit schools, 81 percent of more selective private schools, and 82 percent of for-profit institutions are represented.

[41]Approximately 67 percent of Pell Grant recipients within more selective public schools experience a net increase in institutional grant aid. The switching point in both sectors corresponds to a $4000 Pell Grant (where average AGI is approximately $19,000).

[42]In the model of Epple et al. (2013), students receive idiosyncratic preference shocks for schools in their choice sets, which can rationalize a high degree of crowd out in the private nonprofit sector even when schools do not appear to have substantial market power.

6.2 Evaluating alternative explanations for pricing patterns

Up until this point, I have attributed differences in institutional pricing responses to Pell Grant aid to differences in institutional objectives and market power. However, there are other potential explanations for this behavior. Since public schools charge lower prices than private institutions, institutional aid may mechanically fall if increases in Pell Grant aid drive students' remaining need to zero. State need-based aid may be distributed differently across sectors, further contributing to such mechanical effects.

After accounting for EFC and federal, state, and institutional grant aid, 95 percent of students near the Pell Grant eligibility threshold had remaining need (Table 1).[43] On average, students' unmet need exceeded $10,000. Even students attending nonselective public institutions – schools with the lowest cost of attendance – averaged over $6,500 in unmet need.[44]

Second, student demand elasticities likely vary across demographic groups. If students from these groups differentially select into sectors, differences in pass-through and willingness to pay should be attributed to differences in study body composition rather than differences in school objectives. For instance, even among Pell Grant recipients, selective institutions enroll more students that are white, while public institutions enroll a higher percentage of in-state Pell Grant recipients (Appendix Table C.1). Furthermore, upper year students may be less responsive to price increases, and these students are more likely to be present in selective institutions due to higher rates of persistence. I investigate whether differences in pass-through and willingness to pay for Pell Grant recipients across sectors relate to differences in student characteristics (race, gender, in-state status) and level of attendance (Appendix Table C.5). I group nonselective and selective public institutions and nonselective nonprofit and for-profit institutions, as differences in willingness to pay and pass-through are not statistically distinguishable between these sectors (Table 6).[45] Across all groups, pass-through of Pell Grant aid is significantly greater in selective nonprofit institutions. I find no evidence of statistically distinguishable differences in pass-through of Pell Grant aid for upper year students compared to new college students in any sector.

[43] I define a student's unmet need to equal her total cost of attendance (COA) less EFC and aid from all grants. This differs from the federal definition, which considers work-study and federal loan aid to contribute towards meeting need. However, since these sources of aid are applied after all grant aid is taken into account, they are less relevant for determining whether a student has remaining need for the purposes of providing institutional grant aid. A student's COA differs from tuition and fees in that it also includes living expense (e.g., books and supplies, room and board, transportation). Although in many cases, tuition and fees may be fully covered by grant aid, often a student's COA is more than double this amount. According to the 2015 Digest of Education Statistics (Table 330.10), in 2015, average tuition, fees, room, and board for full-time undergraduate students equaled $21,728, approximately 90 percent higher than average tuition and fees ($11,487). Since the former amount does not include the cost of transportation or books and supplies, the average total cost of attendance is likely at least double that of average tuition and fees. Among public institutions, average tuition represented 39 percent of average tuition, fees, room, and board ($16,188). Among nonprofit institutions, average tuition and fees represented 73 percent of average tuition, fees, room, and board ($41,970) and among for-profit institutions, average tuition and fees represented 60 percent of average tuition, fees, room, and board ($23,372).

[44] Appendix Figures C.8 and C.9 plot the percentage of students with any unmet need and average unmet need and by EFC and sector, where unmet need is defined as $\max\left\{\left(COA - EFC - state\,grants - federal\,grants - institutional\,grants\right), 0\right\}$.

[45] These models also include controls for observable predetermined characteristics to account for correlations between the dimensions of heterogeneity examined and other student characteristics.

Third, students may respond to Pell Grant generosity by upgrading to a higher quality institution. In this case, price increases would be expected, as students are receiving a more valuable product. The scope for upgrading is limited by the fact that most students do not "shop around" for the best price; most entering students only listed one school on their FAFSA. Furthermore, as all models include school by year fixed effects in all models, estimated impacts will abstract from differences across schools in quality and prices. Finally, I find no evidence of discontinuities in observable student characteristics from within-school estimates (Appendix Table C.2). However, upgrading might lead to discontinuities in student characteristics at the threshold that are either not large enough to be detected or not observable in the NPSAS. Thus, I examine correlations between Pell Grant aid and institutional revenue (tuition and total revenue per full-time equivalent (FTE) student), expenditures (institutional grants, instruction-related expenditures, and expenditures on student services per FTE), using data from the IPEDS (Appendix Table C.6).[46] Among returning students, I find little evidence of economically meaningful upgrading (Panel B). Among entering students, there some evidence of a positive relationship between Pell Grant eligibility and institutional expenditures, although visual inspection of this reduced form relationship does not display any evidence of a kink or discontinuity (Appendix Figure C.11).

7 Global Crowd Out

Thus far, I have focused on estimating Pell Grant aid crowd out in the neighborhood of the program's eligibility threshold. With stronger assumptions, I can use the observable relationship between institutional aid and EFC for ineligible students to estimate global crowd out of Pell Grant aid (i.e., the average amount of Pell Grant aid passed through from all recipients to their schools). Specifically, I must assume that the relationship between institutional aid and EFC for ineligible students provides a valid counterfactual for what the relationship between institutional aid and EFC would have been for Pell Grant recipients in the absence of the Pell Grant Program. For this approach to work, heterogeneous treatment effects must be linear, which implies that pass-through of Pell Grant aid and schools' willingness to pay for Pell Grant recipients will be constant in the amount of Pell Grant aid received. This assumption is partially testable, since the location of the Pell Grant eligibility threshold moves as the maximum Pell Grant changes. By using data from earlier NPSAS waves, I trace out the counterfactual institutional aid-EFC relationship for students that are eligible for Pell Grant aid in the current year. Results suggest that, at least over the range of EFC where students gained Pell Grant eligibility, this relationship is linear (Panel A, Figure 8).

[46] IPEDS data on institutional characteristics is only reliable for schools in the 2004 and 2008 NPSAS waves. Thus, impacts on institutional quality can only be estimated for a subset of my main sample. However, estimated effects of Pell Grant eligibility, generosity, and aid received are quite similar for this restricted sample (Appendix Table C.7).

Panel B of Figure 8 illustrates my approach to estimating global crowd out. The shaded area under the Pell Grant schedule ($Total\,Pell$) represents the total amount of aid intended for Pell Grant recipients by the federal government. The solid lines represent the observed relationship between institutional aid and $\widetilde{EFC}$ for eligible and ineligible students, while the light diagonal dashed line represents counterfactual institutional aid for Pell Grant eligible students. In other words, each point along this line represents the predicted amount of institutional aid a student with a particular $\widetilde{EFC}$ would have received had they not been eligible for Pell Grant aid. The difference between the area under the first curve (counterfactual institutional aid) and the second curve (actual institutional aid) represents total pass-through of Pell Grant aid (A–B). The ratio of total pass-through to total Pell Grants, $\frac{A-B}{Total\,Pell}$, represents the percentage of Pell Grant aid captured by institutions.

To estimate the counterfactual institutional aid-$\widetilde{EFC}$ relationship, I restrict the sample to Pell ineligible students and regress institutional aid on $\widetilde{EFC}$ and school and year fixed effects, allowing the relationship between $\widetilde{EFC}$ and institutional aid to vary by sector. The $\widetilde{EFC}$ coefficient and corresponding confidence interval provide estimates of the counterfactual institutional aid Pell Grant recipients would have received if the program did not exist.

Overall, 85 cents of every Pell Grant dollar is passed-through to students; institutions receive the remaining 15 cents (Table 7). Nonselective nonprofit institutions receive 31 cents of every Pell Grant dollar while more selective nonprofit institutions capture 75 cents. In the public sector, net crowd out of Pell Grant aid is only 5 percent. Finally, among for-profit institutions, net crowd out is approximately 5 cents of every Pell Grant dollar.

These estimates will represent the economic incidence of the Pell Grant program given two important caveats. First, my approach does not take into any changes in listed tuition in response to changes in Pell Grant generosity. The majority of Pell Grant recipients attend public schools and, in most states, public institutions lack the ability to raise tuition without approval from their governing body (Turner 2012).[47] On average, more selective private institutions serve few Pell Grant recipients, making it unlikely that these schools would raise tuition for all students to appropriate federal aid provided to a small number of individuals. However, in the case of for-profit institutions, Cellini and Goldin (2014) provide evidence that these schools may respond to federal aid eligibility by increasing tuition, which would suggest my estimates represent a lower bound of the global incidence of Pell Grant aid. If instead, I also incorporate the Cellini and Goldin (2014) estimate of close to 100 percent pass-through of federal aid via tuition increases among for-profits, and given the distribution of Pell Grant recipients across sectors in 2015, back-of-the-envelope estimates of the economic incidence of Pell Grant aid suggests an upper bound of 33 percent.

[47]In 2015, 67 percent of Pell Grant recipients attended public schools (U.S. Department of Education 2016*a*).

Second, my results can only represent the short-run incidence of Pell Grants. In the long-run, increased competition may limit schools' ability to capture publicly funded grants. Although the supply of public institutions is relatively fixed, student aid generosity may lead to for-profit entry (e.g., Cellini 2010). If for-profit institutions retain captured Pell Grant aid as profits, my results provide a rationale for this response. An increase in competition should reduce institutions' ability to capture Pell Grant aid; in the long-run, institutional rents may be driven to zero. Welfare analysis is complicated by the fact that captured Pell Grant funds may ultimately lead to an expansion in the provision of higher education. However, the market for higher education also has substantial barriers to entry, since schools face large fixed costs (e.g., investments in facilities) and must gain accreditation and demonstrate a sufficiently high level of enrollment for two years before their students are eligible for Pell Grant aid. Thus, I leave the analysis of the long-run incidence of the Pell Grant Program to future work.

8 Conclusions

Although low-income students are the statutory recipients of Pell Grant aid, they do not receive the full benefit of these subsidies. Using a combined RD/RK approach, I estimate the impact of Pell Grants on institutional grants and show that schools respond to increases in federal grant aid by systematically altering prices. Overall, I find that institutions capture 11 to 20 percent of all Pell Grant aid. This is substantially lower than the degree of crowd out estimated for other sources of student aid (Long 2004; Turner 2012; Bettinger and Williams 2015).

RK and RD designs yield conflicting estimates of the impact of Pell Grant aid on college pricing, with RK estimates suggesting schools capture Pell Grant aid and the RD estimator implying schools supplement Pell Grants with increased institutional aid. I show that these disparate estimates can be reconciled using a framework in which schools place different weights on students with different characteristics. In this case, the "treatment" of Pell Grant aid has two dimensions: the additional dollar of outside aid that the school would like to capture and the school's willingness to pay for Pell Grant recipients. With this particular form of treatment heterogeneity, the RD design can only identify the reduced form impact of these two responses, and for RD estimates, schools' willingness to pay dominates their ability to capture outside aid. Using the combined RD/RK approach, I estimate that less than one third of Pell Grant recipients benefit from these transfers, since schools' ability to capture Pell Grant aid quickly overtakes their willingness to pay for needy students. My paper is the first to combine RD and RK estimators to distinguish between different treatment dimensions.

My paper also provides insight into the industrial organization of higher education. I show how schools' responses to Pell Grant aid can be rationalized by differences in schools' objectives. Under the stronger assumption that the distribution of institutional aid to ineligible students near the threshold provides a valid counterfactual for the distribution of institutional aid in the absence of the Pell Grant Program, I calculate that schools capture 15 percent of all Pell Grant aid. In 2015, the federal government distributed $30.6 billion in Pell Grants to 8.3 million students. My results suggest that institutions captured at least $4.6 billion of this aid.

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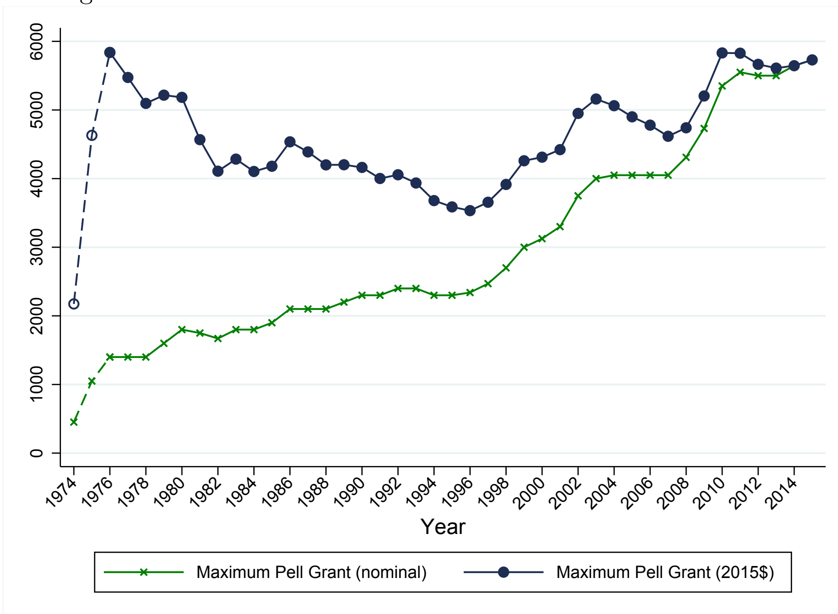
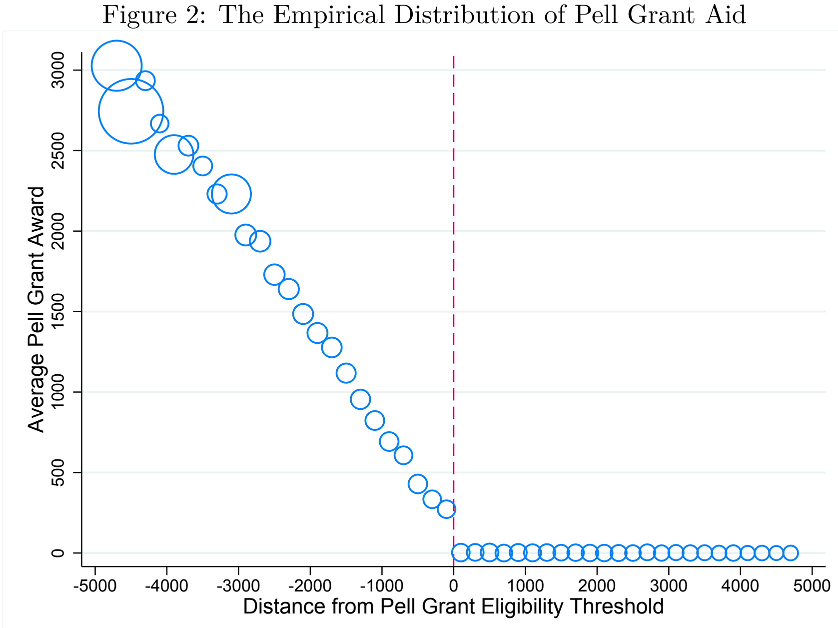
Figures and Tables

Figure 1: Time Series Variation in Maximum Pell Grant Award



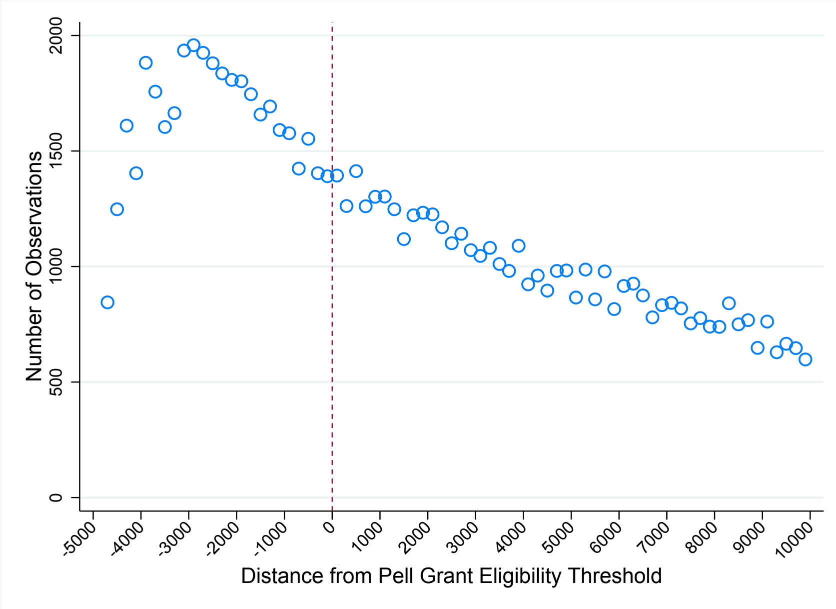
Source: U.S. Department of Education (2016*a*) and https://ifap.ed.gov/dpcletters/GEN1502.html. *Notes:* Dashed lines indicate years in which the Pell Grant Program was partially implemented (1974 and 1975).

Figure 2: The Empirical Distribution of Pell Grant Aid



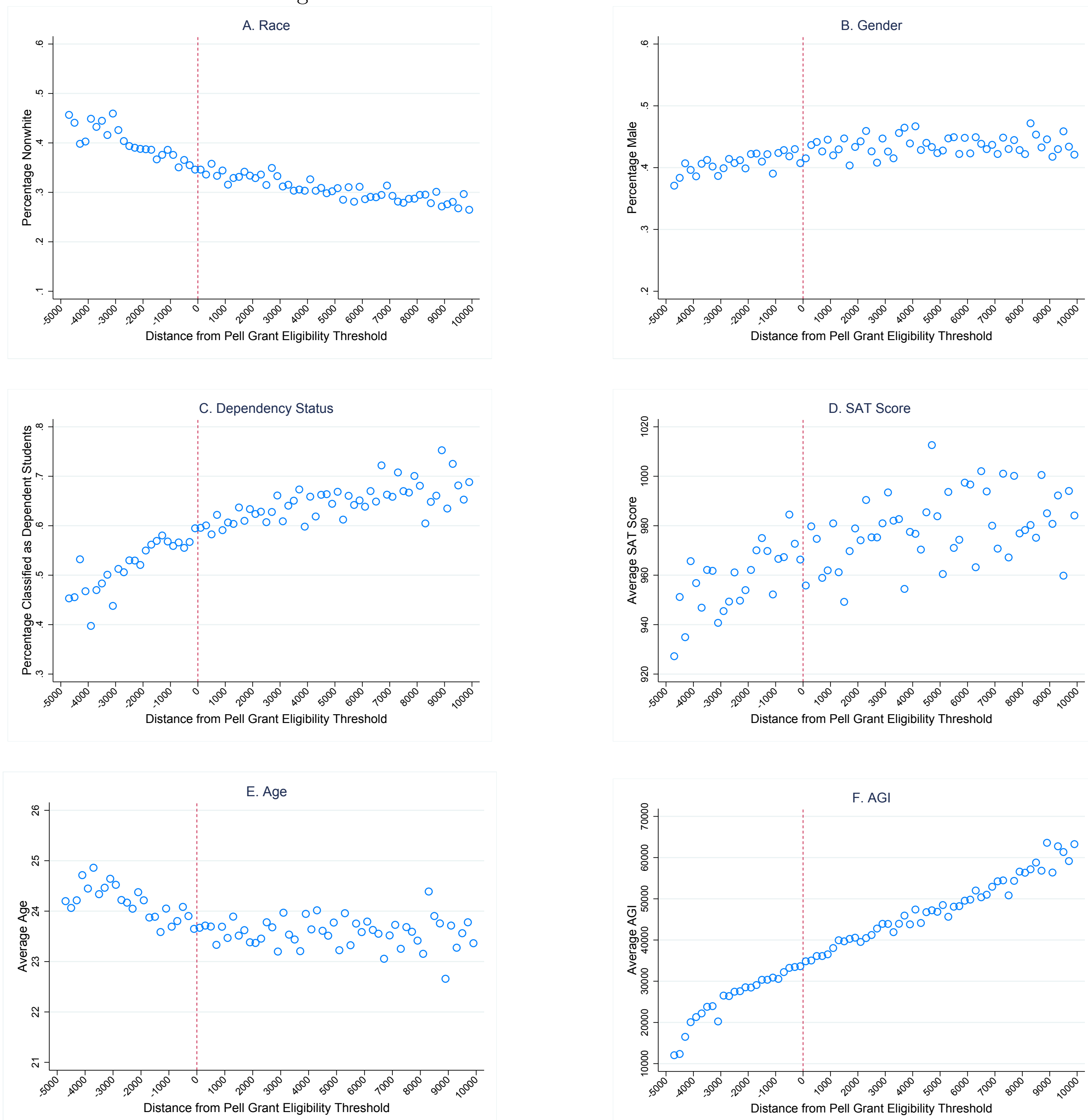
Source: 1996, 2000, 2004, and 2008 NPSAS. See Appendix B for sample construction details. *Notes:* Each circle represents the average Pell Grant received by students with standardized expected family contribution ($\widetilde{EFC}_{it} = EFC_{it} - efc^0_t$, where efc^0_t is the threshold for Pell Grant eligibility in year t) within a given \$200 bin. All dollar amounts adjusted for inflation using the CPI-U and reported in 2013 dollars.

Figure 3: The Density of EFC at the Pell Grant Eligibility Threshold



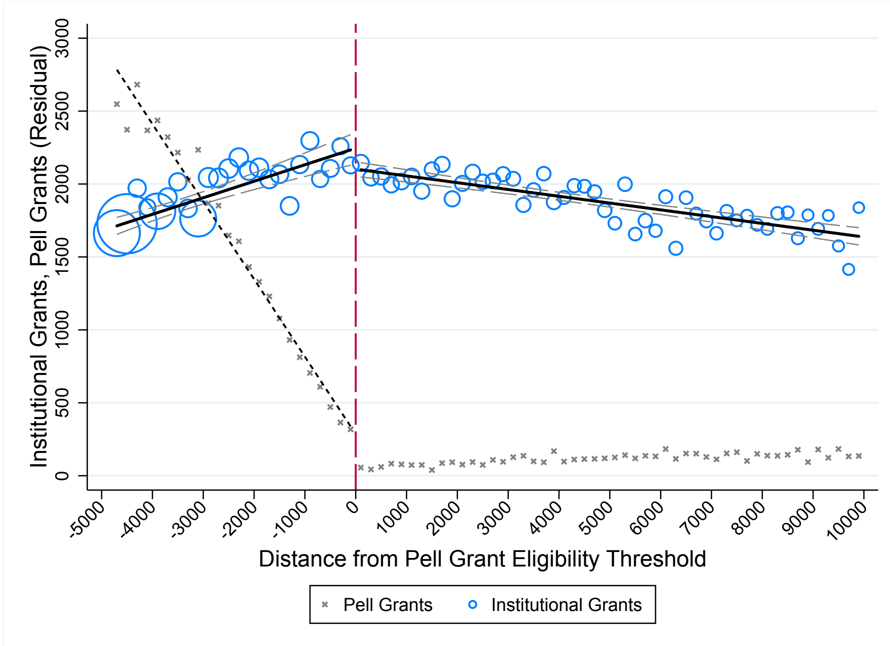
Source: 1996, 2000, 2004, and 2008 NPSAS. *Notes*: See Appendix B for sample construction details. \$200 $\widetilde{EFC}$ bins; each circle represents the number of students in the bin. All dollar amounts adjusted for inflation using the CPI-U and reported in 2013 dollars.

Figure 4: The Distribution of Baseline Characteristics



Source: 1996, 2000, 2004, and 2008 NPSAS. See Appendix B for sample construction details. *Notes*: \$200 $\widetilde{EFC}$ bins; each circle represents the mean characteristic for students in the bin (recentered residuals from a regression on institution by year fixed effects). All dollar amounts adjusted for inflation using the CPI-U and reported in 2013 dollars.

Figure 5: Pell Grant Generosity and Institutional Aid by EFC



Source: 1996, 2000, 2004, and 2008 NPSAS. See Appendix B for sample construction details. *Notes*: \$200 EFC bins. The black solid line represents a linear fit of average institutional grant aid (recentered residuals from a regression with school and year fixed effects) on $\widetilde{EFC}_{it}$, estimated separately on each side of the Pell Grant eligibility threshold; gray dashed lines are 95 percent confidence intervals. The thin black dashed line is a linear fit of Pell Grant aid (residuals from a regression on school and year fixed effects) on EFC. Larger circles indicate a larger number of students. All dollar amounts adjusted for inflation using the CPI-U and reported in 2013 dollars.

Figure 6: Pell Grant Generosity and Institutional Aid by Sector

A. Public Institutions

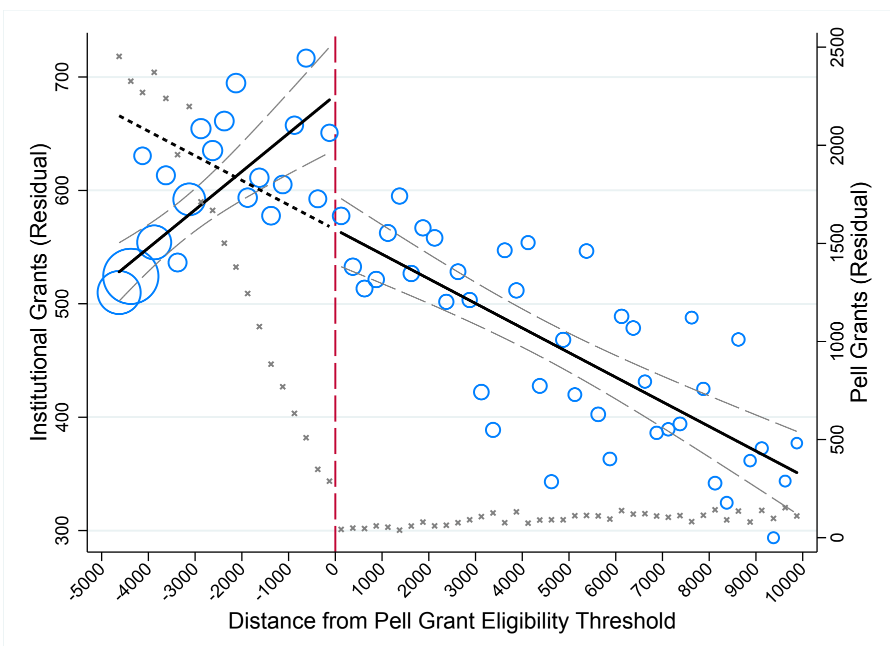
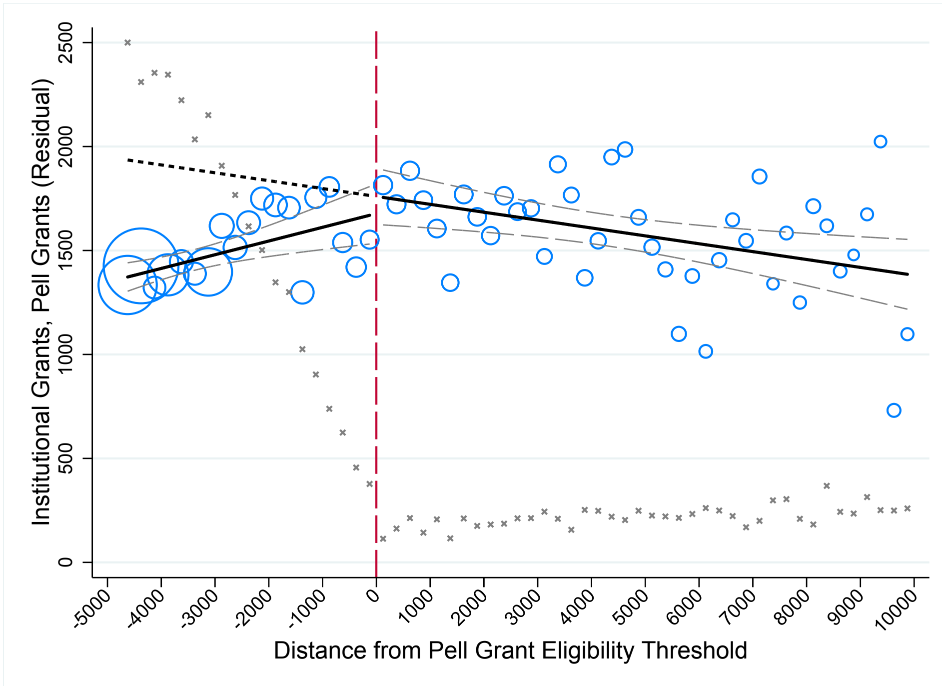
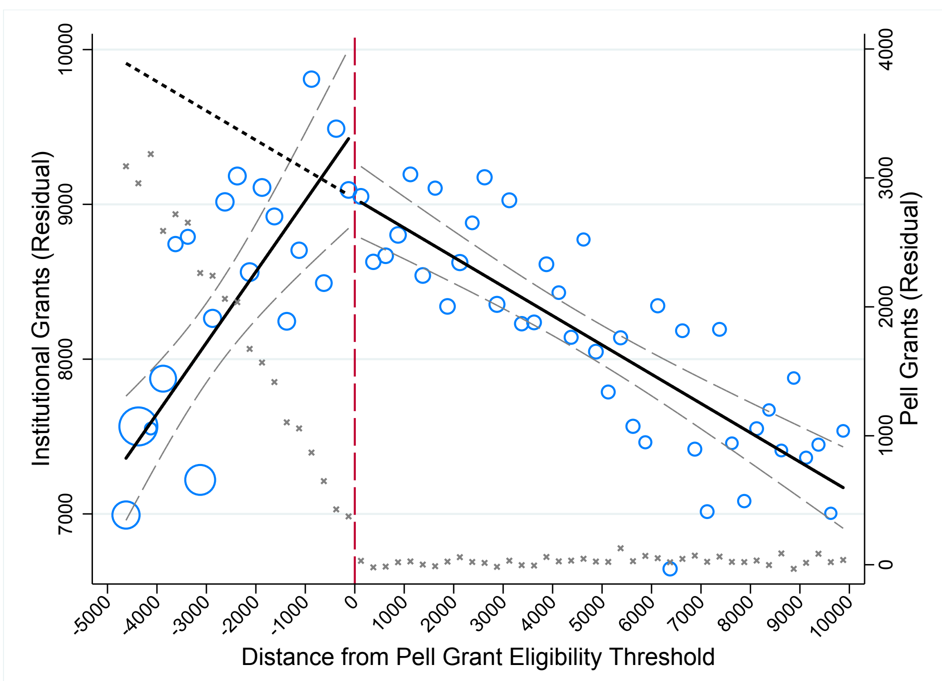


Figure 6, continued

B. Nonselective Private Institutions

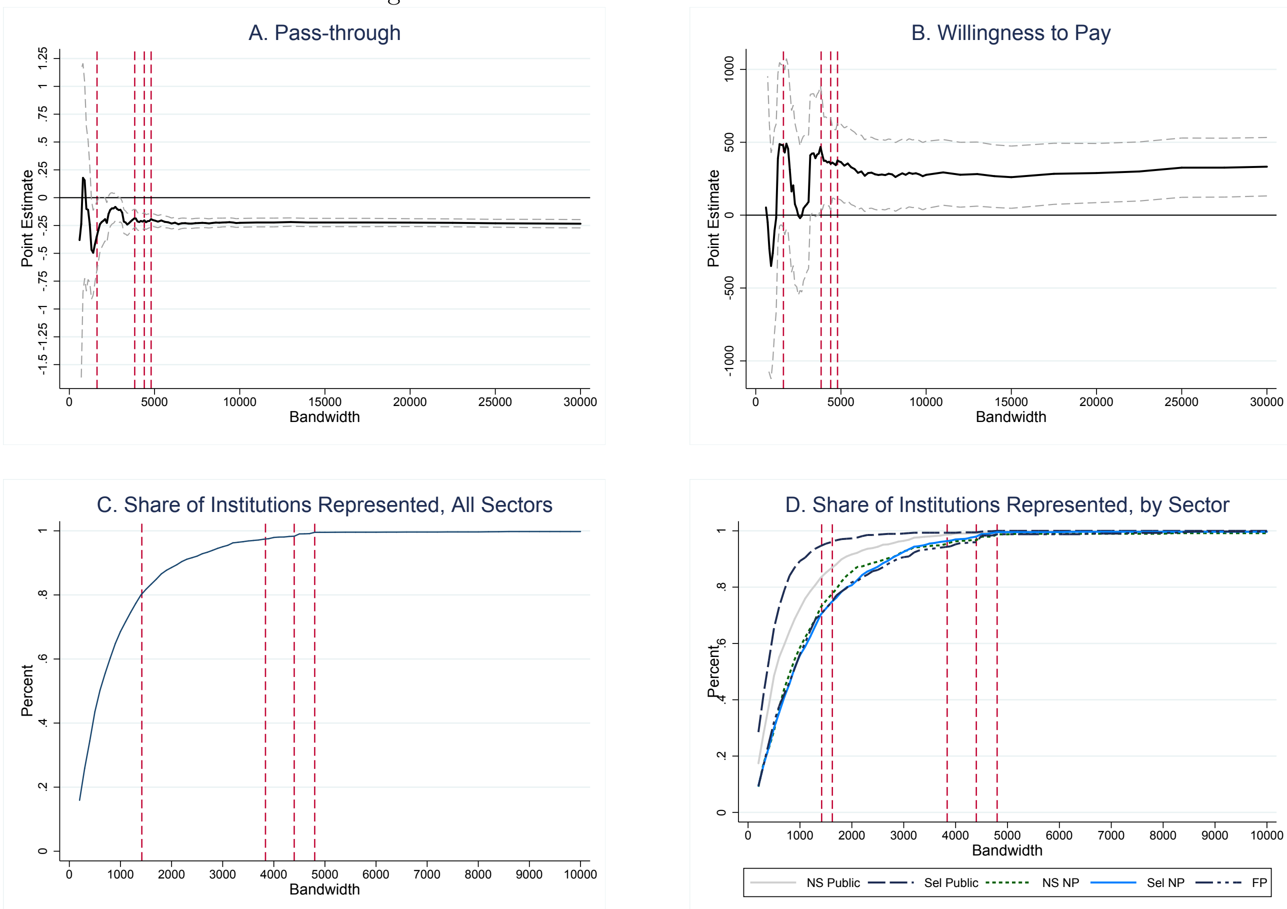


C. More Selective Nonprofit Institutions



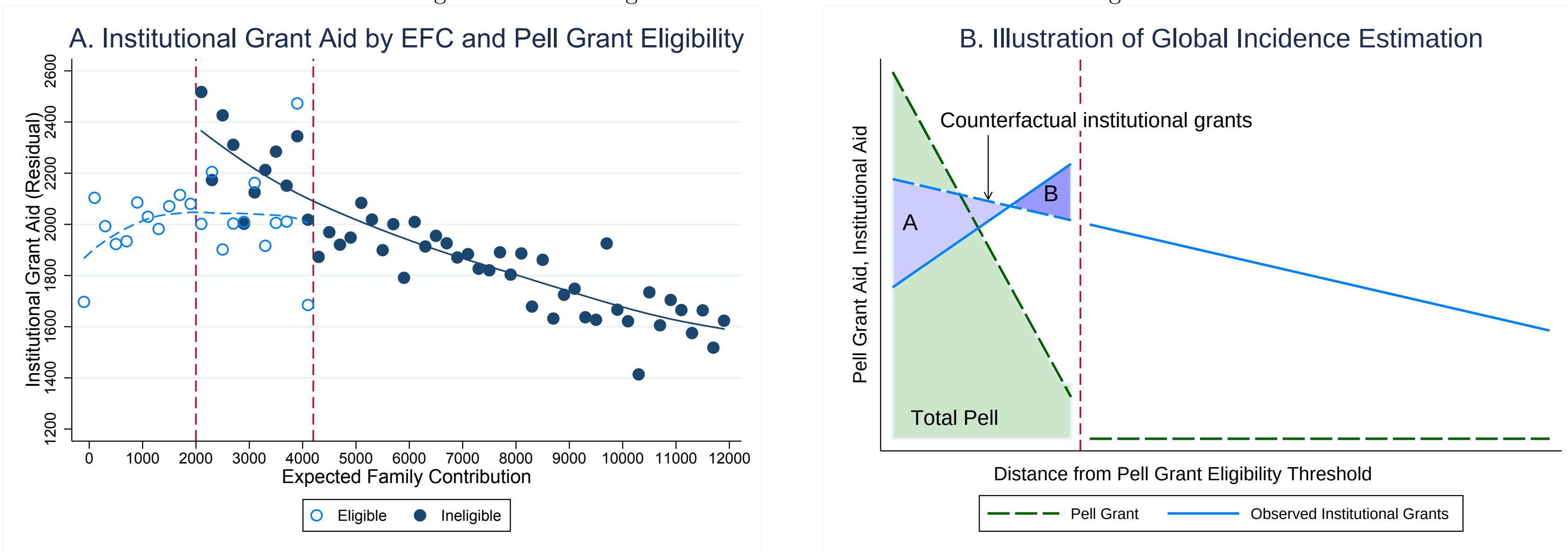
Source: 1996, 2000, 2004, and 2008 NPSAS. See Appendix B for sample construction details. *Notes*: $250 EFC bins. The black solid line represents a linear fit of average institutional grant aid (recentered residuals from a regression with school and year fixed effects) on $\widetilde{EFC}$, estimated separately on each side of the Pell Grant eligibility threshold; gray dashed lines are 95 percent confidence intervals. The thin black dashed line represents predicted institutional grant aid using the relationship between institutional grant aid and EFC for Pell Grant ineligible students. Larger circles indicate a larger number of students. All dollar amounts adjusted for inflation using the CPI-U and reported in 2013 dollars.

Figure 7: Robustness of Estimates to Bandwidth



Source: 1996, 2000, 2004, and 2008 NPSAS. See Appendix B for sample construction details. *Notes*: Panels A and B display IV estimates from a regression of institutional grant aid on Pell Grant aid using varying windows around the Pell Grant eligibility threshold (e.g., a bandwidth = 5000 only includes students with an EFC within 5,000 of this threshold); the black solid line represents point estimates for each bandwidth and the light gray dashed lines represent the corresponding 95 percent confidence intervals (standard errors clustered at institution by year level). See Section 6 for definitions and estimation of treatment dimensions. All models include school by year fixed effects, $\widetilde{EFC}_{it}$ allowed to vary by year, $\mathbf{1}[\widetilde{EFC}_{it} < 0]$, and $\widetilde{EFC}_{it}\mathbf{1}[\widetilde{EFC}_{it} < 0]$. Panels C and D display the share of all NPSAS institution by year observations that are included in a given bandwidth. All dollar amounts adjusted for inflation using the CPI-U and reported in 2013 dollars.

Figure 8: Estimating the Global Incidence of the Pell Grant Program



Source: 1996, 2000, 2004, and 2008 NPSAS. See Appendix B for sample construction details. *Notes*: Panel A – each circle represents the institutional grant aid received by students within a given $200 EFC bin, with dark solid circles representing Pell Grant ineligible students and light hollow circles representing Pell Grant eligible students. The vertical dashed lines represent the range of EFC within which students gained Pell Grant eligibility between 1996 and 2008. The dark solid line represents predicted institutional grant aid from a local linear regression of institutional grant aid on EFC among Pell Grant ineligible students; the light dashed line represents the same for Pell Grant eligible students. EFC in nominal dollars, institutional grant aid is adjusted for inflation using the CPI-U and reported in 2013 dollars. Panel B – the area labeled Total Pell represents the total amount of Pell Grant aid disbursed to students. The areas A and B represent the difference between the area below the counterfactual institutional grant aid-EFC relationship (represented by the dashed line) and the actual institutional grant aid-EFC relationship for Pell eligible students (represented by the solid line); A-B represents the amount of institutional grant aid students failed to receive due to the Pell Grant Program. See Section 7 for additional details.

Table 1: Characteristics of Schools and Students by Pell Grant Receipt

	(1) Pell Grant recipients	(2) Nonrecipients	(3) Full sample
A. Cost of attendance and financial aid			
Expected family contribution	$779	$3,448	$1,979
Cost of attendance	$17,921	$15,183	$16,690
Pell Grant aid	$2,918	$0	$1,606
State grant aid	$1,200	$478	$875
Other federal grant aid	$338	$20	$195
Institutional grant aid	$1,681	$1,433	$1,570
Percent receiving institutional aid	0.30	0.22	0.27
Unmet need	$10,733	$9,472	$10,166
Percent with unmet need	0.99	0.90	0.95
B. Student demographic characteristics			
White	0.52	0.68	0.59
Male	0.37	0.45	0.40
Dependent student	0.48	0.54	0.51
Age	24	24	24
In-state	0.91	0.88	0.89
Adjusted gross income	$18,183	$32,454	$24,439
C. Student attendance status			
Full-time	0.79	0.67	0.73
Months of enrollment	11	10	10
D. Institution selectivity and control			
Nonselective public	0.64	0.72	0.68
More selective public	0.21	0.26	0.23
Nonselective nonprofit	0.11	0.08	0.09
More selective nonprofit	0.11	0.13	0.12
For-profit	0.14	0.07	0.11
Number of students	57,400	46,910	104,300

Source: 1996, 2000, 2004, and 2008 NPSAS. *Notes*: See Section 3 for definitions of selectivity and control. Students with EFC greater than $4,800 from Pell Grant eligibility threshold are excluded. Sample also excludes graduate and professional students, students attending multiple institutions during the academic year, students not enrolled in the fall semester, athletic scholarship recipients, noncitizens, and students attending nondegree granting institutions, theological seminaries, or other faith-based institutions. See Appendix B for further details. Cost of attendance equals tuition and fees, books and supplies, and room and board, transportation, and other living expenses. Total need equals $max\left\{(COA - EFC), 0\right\}$. Unmet need equals $max\left\{COA - EFC - grants, 0\right\}$, where grants includes state, federal, and institutional grant aid. Cost of attendance (COA) includes tuition and fees, room and board, books and supplies, transportation, and other living expenses. All dollar amounts adjusted for inflation using the CPI-U and reported in 2013 dollars.

Table 2: RK and RD Estimates of the Impact of Pell Grant Aid on Institutional Aid

	OLS		IV	
	(1) FS	(2) RF	(3) RK	(4) RD
Change in slope	-0.616	0.119		
	(0.005)**	(0.018)**		
Change in level	189	108		
	(11)**	(53)*		
Pell Grant Aid			-0.193	0.573
			(0.029)**	(0.275)*
F-test of excluded instrument			15144	318
Test of equality (*p* -value)			0.005	
Observations	104,300	104,300	104,300	104,300

Source: 1996, 2000, 2004, and 2008 NPSAS. *Notes*: Each column contains estimates from separate regressions. Students with EFC greater than \$4,800 from Pell Grant eligibility threshold are excluded. See Table 1 notes for additional sample restrictions. Number of observations rounded to nearest 10. Standard errors clustered at institution by year level in parentheses; ** p<0.01, * p<0.05, + p<0.1. All regressions include school by year fixed effects, student expected family contribution ($\widetilde{EFC}_{it} = EFC_{it} - efc_t^0$, where efc_t^0 is the threshold for Pell Grant eligibility in year t) allowed to vary by survey year, an indicator for Pell Grant eligibility ($\mathbf{1}[\widetilde{EFC}_{it} < 0]$), and the interaction between Pell Grant eligibility and distance from the eligibility threshold ($\widetilde{EFC}_{it}\mathbf{1}[\widetilde{EFC}_{it} < 0]$). In column 3 model, $\mathbf{1}[\widetilde{EFC}_{it} < 0]$ serves as the excluded instrument. In column 4 model, $\widetilde{EFC}_{it}\mathbf{1}[\widetilde{EFC}_{it} < 0]$ serves as the excluded instrument. All dollar amounts adjusted for inflation using the CPI-U and reported in 2013 dollars.

Table 3: Robustness of RK and RD Estimates to Varying Bandwidths

	OLS		IV	
	(1) FS	(2) RF	(3) RK	(4) RD
A. Imbens and Kalyanaraman (2012)				
Change in slope	-0.646	0.125		
	(0.011)**	(0.028)**		
Change in level	144	104		
	(9)**	(61)+		
Pell Grant aid			-0.195	0.676
			(0.042)**	(0.384)+
Test of equality (*p* -value)			0.027	
Bandwidth	1966	3837	3837	3837
Percent of institutions	0.88	0.97	0.97	0.97
Observations	27,790	60,280	60,280	60,280
B. Fan Gijbels (1996) rule of thumb bandwidth				
Change in slope	-0.604	0.128		
	(0.013)**	(0.023)**		
Change in level	170	87		
	(10)**	(58)		
Pell Grant aid			-0.204	0.499
			(0.036)**	(0.324)
Test of equality (*p* -value)			0.032	
Bandwidth	1569	4399	4399	4399
Percent of institutions	0.83	0.98	0.98	0.98
Observations	21,710	72,370	72,370	72,370
C. Calonico, Cattaneo, and Titiunik (2014)				
Change in slope	-0.520	0.284		
	(0.026)**	(0.112)*		
Bandwidth	798	1418		
Percent of institutions	0.60	0.80		
Observations	10,190	19,570		
Change in level	213	74		
	(11)**	(91)		
Bandwidth	676	1624		
Percent of institutions	0.54	0.84		
Observations	8,460	22,510		
Pell Grant aid			-0.475	0.451
			(0.188)*	(0.550)
Test of equality | bw (*p* -value)			0.091	0.171
Observations			19,570	22,510

Source: 1996, 2000, 2004, and 2008 NPSAS. *Notes*: Each column within a panel contains estimates from separate regressions. Students with EFCs outside of the bandwidth chosen using the specified method are excluded. CCT bandwidths are estimated using the `rdbwselect` Stata command. See Table 1 notes for additional sample restrictions. Number of observations rounded to nearest 10. Standard errors clustered at institution by year level in parentheses; ** p<0.01, * p<0.05, + p<0.1. All regressions include school by year fixed effects, $\widetilde{EFC}_{it}$ allowed to vary by survey year, $\mathbf{1}[\widetilde{EFC}_{it} < 0]$, and $\widetilde{EFC}_{it}\mathbf{1}[\widetilde{EFC}_{it} < 0]$. $\mathbf{1}[\widetilde{EFC}_{it} < 0]$ serves as excluded instrument in IV-RD models; $\widetilde{EFC}_{it}\mathbf{1}[\widetilde{EFC}_{it} < 0]$ serves as excluded instrument in IV-RK models. "Percent of institutions" indicates the share of all NPSAS institutions represented within the specified bandwidth. All dollar amounts adjusted for inflation using the CPI-U and reported in 2013 dollars.

Table 4: RK and RD Estimates: Additional Robustness Tests

	(1) IV-RK		(2) IV-RD
A. Accounting for other grant aid			
Federal and state grant aid	-0.193		0.292
	(0.030)**		(0.140)*
Test of equality (*p* -value)		0.001	
Observations	104,300		104,300
B. Dropping institutions that meet full need			
Pell Grant Aid	-0.185		0.540
	(0.029)**		(0.275)*
Test of equality (*p* -value)		0.008	
Observations	103,600		103,600
C. Dropping institutions that do not give out institutional aid			
Pell Grant Aid	-0.209		0.601
	(0.031)**		(0.283)*
Test of equality (*p* -value)		0.004	
Observations	94,070		94,070
D. Using sampling weights			
Pell Grant Aid	-0.158		0.353
	(0.029)**		(0.318)
Test of equality (*p* -value)		0.110	
Observations	104,300		104,300
E. Controls for predetermined characteristics			
Pell Grant Aid	-0.169		0.573
	(0.029)**		(0.282)*
Test of equality (*p* -value)		0.008	
Observations	104,300		104,300
F. Excluding fixed effects			
Pell Grant Aid	-0.419		1.771
	(0.045)**		(0.376)**
Test of equality (*p* -value)		<0.001	
Observations	104,300		104,300

Source: 1996, 2000, 2004, and 2008 NPSAS. *Notes*: Each column within a panel contains estimates from separate regressions. Students with EFC greater than $4,800 from Pell Grant eligibility threshold are excluded. See Table 1 notes for additional sample restrictions. Standard errors clustered at institution by year level in parentheses; ** p<0.01, * p<0.05, + p<0.1. See Table 2 notes for description excluded instruments. In Panel A, Pell Grant aid is replaced with the sum of federal and state grant aid. In Panel B, students attending institutions that have pledged to meet full need in the survey year are excluded (see Section 5 for details). In Panel C, students attending institutions that do not provide institutional aid in any NPSAS wave are excluded. Panel D models are weighted with the NPSAS sampling weights. Panel E models also include controls for gender, race, class level, dependency status, and out-of-state student, and linear and quadratic terms in age, while Panel F models only include controls for $\widetilde{EFC}_{it}$ (allowed to vary by survey year) and excluded instruments. All dollar amounts adjusted for inflation using the CPI-U and reported in 2013 dollars.

Table 5: RK and RD Estimates: Impacts on Total Grants and Prices

	(1) IV-RK	(2) IV-RD
A. Total grant aid		
Pell Grant Aid	0.798	2.801
	(0.034)**	(0.324)**
Test H_0: coeff = 1 (*p* -val)	<0.001	<0.001
Test of equality (*p* -value)	<0.001	
B. Effective price (list price - institutional aid)		
Pell Grant Aid	0.214	-0.637
	(0.033)**	(0.301)*
Test of equality (*p* -value)	0.004	
C. Final price (list price - all grant aid)		
Pell Grant Aid	-0.777	-2.865
	(0.036)**	(0.334)**
Test H_0: coeff = 1 (*p* -val)	<0.001	<0.001
Test of equality (*p* -value)	<0.001	
Observations	104,300	104,300

Source: 1996, 2000, 2004, and 2008 NPSAS. *Notes*: Each cell within a panel contains estimates from separate regressions. Total grant aid equals the sum of all federal, state, and institutional grants. Number of observations rounded to nearest 10. Students with EFC greater than $4,800 from Pell Grant eligibility threshold are excluded. See Table 1 notes for additional sample restrictions. Standard errors clustered at institution by year level in parentheses; ** p<0.01, * p<0.05, + p<0.1. All regressions include school by year fixed effects, $\widetilde{EFC}_{it}$ allowed to vary by year, $\mathbf{1}[\widetilde{EFC}_{it} < 0]$, and $\widetilde{EFC}_{it}\mathbf{1}[\widetilde{EFC}_{it} < 0]$. $\mathbf{1}[\widetilde{EFC}_{it} < 0]$ serves as excluded instrument in IV-RD models; $\widetilde{EFC}_{it}\mathbf{1}[\widetilde{EFC}_{it} < 0]$ serves as excluded instrument in IV-RK models. All dollar amounts adjusted for inflation using the CPI-U and reported in 2013 dollars.

Table 6: The Impact of Pell Grant Aid on Institutional Aid: Treatment Dimensions

	Pass-through	Willingness to pay
A. All institutions	-0.193	375
	(0.029)**	(133)**
Observations	104,300	
B. By sector		
Nonselective public	-0.054	88
	(0.015)**	(235)
More selective public	-0.121	483
	(0.038)**	(149)**
Nonselective nonprofit	-0.080	197
	(0.103)	(519)
More selective nonprofit	-0.925	1170
	(0.167)**	(424)**
For-profit	-0.091	-163
	(0.055)+	(168)
Tests of equality (*p* -value):		
All sectors	<0.001	0.009
Public institutions	0.102	0.155
Private institutions	<0.001	0.013
Nonselective institutions	0.800	0.607
More selective institutions	<0.001	0.126
NS nonprofit = for-profit	0.929	0.522
Observations	104,300	

Source: 1996, 2000, 2004, and 2008 NPSAS. *Notes*: Each panel contains estimates from separate models. Number of observations rounded to nearest 10. Students with EFC greater than $4,800 from Pell Grant eligibility threshold are excluded. See Table 1 notes for additional sample restrictions. Standard errors clustered at institution by year level in parentheses; ** p<0.01, * p<0.05, + p<0.1. See Section 6 for definitions and estimation of treatment dimensions. All models include school by year fixed effects, $\widetilde{EFC}_{it}$ allowed to vary by year, $\mathbf{1}[\widetilde{EFC}_{it} < 0]$, and $\widetilde{EFC}_{it}\mathbf{1}[\widetilde{EFC}_{it} < 0]$. Panel B model includes interactions between sector dummies and $\widetilde{EFC}_{it}$, $\mathbf{1}[\widetilde{EFC}_{it} < 0]$, and $\widetilde{EFC}_{it}\mathbf{1}[\widetilde{EFC}_{it} < 0]$. All dollar amounts adjusted for inflation using the CPI-U and reported in 2013 dollars.

Table 7: Global Crowd Out

	Percent captured	95% Confidence interval
All Institutions	0.151	[0.11, 0.20]
By Sector:		
Public institutions	0.040	[0.01, 0.06]
Nonselective nonprofit institutions	0.308	[0.17, 0.45]
More selective nonprofit institutions	0.751	[0.55, 0.95]
For-profit institutions	0.053	[-0.03, 0.13]

Source: 1996, 2000, 2004, and 2008 NPSAS. *Notes*: These estimates assume the observed institutional aid-EFC relationship for Pell ineligible students is a valid counterfactual for Pell eligible students in the absence of the Pell Grant Program. The overall percentage of Pell Grant aid captured by institutions is equal to the ratio of the difference between the area below the counterfactual Pell Grant-EFC curve and the actual Pell Grant-EFC curve and the overall transfer of Pell Grant aid to eligible students (see Section 7 for details). All dollar amounts adjusted for inflation using the CPI-U and reported in 2013 dollars.