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Borrowing Trouble? Student Loans, the Cost of Borrowing, and Implications for the Effectiveness of Need-Based Grant Aid*

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Abstract

In this paper, we estimate the impact of need-based grant aid on City University of New York students' borrowing and educational attainment using regression discontinuity and regression kink designs. Pell Grant aid reduces borrowing: on average, an additional dollar of Pell Grant aid leads to \$0.43 reduction in federal loans. Among borrowers, a dollar of Pell Grant aid crowds-out over \$1.80 of loans. A simple model illustrates that our findings are consistent with students facing a fixed cost of incurring debt. The presence of such a fixed cost may lead to the unintended consequence of additional grant aid decreasing some students' attainment. Empirically, we can rule out modest impacts of Pell Grant aid on effort, persistence, and attainment. Finally, we show that the fixed cost has economically meaningful impacts on behavior: we estimate that relaxing it would increase borrowing by over 300 percent.

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1 Introduction

In the United States, federal and state governments provide substantial subsidies to college students, with the intention of increasing low-income individuals' educational attainment. During the 2011-12 academic year, the U.S. Department of Education provided \$34 billion in Pell Grant aid and \$59 billion in federal direct loans to undergraduate students (U.S. Department of Education 2013).[1] Although many students are eligible for both Pell Grants and federal loans, little is known about how these programs interact, how grant aid affects students' borrowing decisions, and the extent to which borrowing responses reduce the ability of grant aid to increase human capital.

In this paper, we use a combined regression discontinuity/regression kink design to identify the impact of need-based grant aid on college students' educational investment decisions, focusing on borrowing and educational attainment. We study City University of New York (CUNY) students who are eligible or nearly eligible for a Pell Grant. Pell Grant aid has large, negative, and statistically significant impacts on borrowing. We estimate that a dollar increase in Pell Grant aid induces first-year students to reduce borrowing by \$0.43, on average. Furthermore, Pell Grant aid crowds out over 100 percent of loan aid among borrowers – with an additional dollar of Pell Grant aid leading these students to reduce borrowing by approximately \$1.80 – a result at odds with traditional models of human capital investment under credit constraints.[2]

Crowd-out in excess of 100 percent can result when preferences or budget sets are discontinuous, as in the case of a fixed cost of borrowing. College students do not pay a monetary fixed cost of borrowing, but may face cognitive, psychic, and time-related costs. We develop a simple two-period model of students' joint borrowing and schooling choices that generates testable predictions for these decisions in the presence of a fixed cost. A marginal increase in grant aid only increases educational attainment of students at a borrowing threshold, such as a credit constraint (e.g., Becker 1975; Cameron and Taber 2004; Lochner and Monge-Naranjo 2011). When students face a fixed cost of incurring debt, our model generates ambiguous predictions for the average impact grant aid on educational attainment. A small increase in grant aid may *reduce* educational attainment among students whose optimal debt is shifted to a level at which the fixed cost binds. Conversely, grant aid increases attainment of students at a borrowing threshold. Thus, the overall educational impacts need-based grant aid likely to vary considerably with the degree to which students can smoothly adjust their borrowing. Empirically, we can rule out all but modest impacts of Pell Grant aid on attainment for students near the Pell Grant eligibility threshold, such as an additional \$1000 of Pell Grant aid increasing cumulative credits obtained three years after college entry by more than 2.6.

[1] Total student loan disbursements calculated from Title IV Program Volume Reports, available at: http://studentaid.ed.gov/about/data-center/student/title-iv.

[2] Unless otherwise noted, all dollar amounts are inflated to 2012 dollars using the CPI-U.

We provide evidence supporting the existence of a fixed cost of borrowing. Borrowing responses to Pell Grants occur primarily along the extensive margin with quantile treatment effects suggesting that the impact of Pell Grant aid on student loan debt is smaller at higher quantiles. Using a maximum likelihood estimator with borrowing thresholds treated as random effects, we estimate that relaxing this cost would increase the probability of borrowing by over 300 percent .

Our primary identification strategy uses nonlinearities in the Pell Grant Program's formula to estimate the causal effect of grant aid on borrowing and attainment for students near the program's eligibility threshold. A naïve regression of these outcomes on grant aid will conflate the effect of aid with the effect of unobserved factors that are correlated with aid, such as motivation or family support. To overcome this concern, we use regression discontinuity (RD) and regression kink (RK) designs (Hahn et al. 2001; Card et al. 2012). While a student's Pell Grant aid depends on the federal government's measure of need, this relationship is discontinuous at the Pell Grant eligibility threshold, causing students with similar characteristics to receive significantly different amounts of aid (Turner 2013).

Our paper contributes to the large literature on the effectiveness of financial aid programs in promoting educational attainment and highlights the importance of considering interactions between programs. Existing estimates suggest that increases in grant aid have the same impact on college attendance as tuition decreases of a similar magnitude, as long as the grant application process is relatively simple. In general, a $1000 increase in financial aid (or decrease in tuition) increases the probability of college attendance by approximately 4 percent (Deming and Dynarski 2010).[3] The Pell Grant Program aims to relax credit constraints and students targeted by the Pell Grant Program are especially needy. Among first-year, Pell Grant-eligible CUNY students in our sample, the average award ($2,394) represents 5 percent of family adjusted gross income and 21 percent of the total cost of attendance.[4] Despite the program's generosity, Pell Grant aid has not been found to increase college enrollment for most low-income students (Kane 1995).[5] Bettinger (2004) finds positive impacts of Pell Grant aid on persistence, but does not consider interactions between Pell Grant aid and borrowing.

[3]Fewer studies examine how grant aid affects attainment conditional on enrollment. Angrist et al. (2009) study a program where students attending a non-selective Canadian public university were randomly assigned to earn aid based on maintaining a minimum GPA and course load. Male students were not affected, but the program had a small impact on the GPAs of female students that were also assigned to receive additional services, such as peer advising and study groups. Scott-Clayton (2011) finds that a conditional merit-aid program in West Virginia, where recipients were required to meet minimum GPA and credit requirements to receive aid, increased educational attainment and graduation rates. Castleman and Long (2012) examine the impact of Florida's need-based grant program on college enrollment and educational attainment, and find that first year eligibility for grant aid increases credits earned and degree completion. Finally, Goldrick-Rab et al. (2014) show that Pell Grant recipients randomly assigned to receive additional aid through the Wisconsin Scholars Grant experienced larger increases in persistence when the additional grant aid did not displace funds from federal loans.

[4] Nationwide, the average Pell Grant award represented 17 percent of average annual income in 2012 (U.S. Department of Education 2013).

[5]Bettinger et al. (forthcoming) provide evidence that the complexity of the federal student aid application process substantially reduces the impact of Pell Grant eligibility on college-going. However, Seftor and Turner (2002) estimate that the introduction of the Pell Grant program did increase enrollment of non-traditional, older students.

We also investigate the factors contributing to the fixed cost of borrowing faced by CUNY students. Using a nationally representative sample of college students, we provide suggestive evidence that Pell Grant aid has larger impacts on CUNY students' borrowing than the average public school student. To the extent that students within and outside the CUNY system face similar psychic costs of borrowing and that offered loans do not vary with Pell Grant eligibility, these results suggest that additional factors contribute to the fixed cost of borrowing faced by CUNY students. Access to federal loan aid in the CUNY system differs from other schools along two key dimensions. First, the default loan offer in the CUNY system is $0, while most other schools offer eligible students nonzero loan awards. Second, CUNY students must opt into borrowing by filling out an additional application for loans. Although we cannot directly test the importance of these these two features of the CUNY borrowing process, we show that students that have access to online loan applications, and thus face lower administrative costs of applying for loan aid, behave no differently than students who must submit their application in person.

Our hypothesis that the fixed cost of borrowing depends on the presentation of student loan offers is consistent with the literature on the importance of default options. For example, Pallais (forthcoming) examines an increase in the number of free score reports ACT test-takers can send to colleges. She estimates that reducing the price of the fourth ACT score report from $6 to $0 had substantial impacts on the quality of college attended by low-income students. Field (2009) studies an experiment conducted by New York University's law school, where prospective students were randomly assigned to receive either debt forgiveness or a tuition waiver tied to taking a job in the public sector. Although both options had the same present discounted value, tuition waiver recipients were significantly more likely to enter into a public sector career.Mandrian and Shea (2001) and Choi et al. (2006) show that default options matter for decisions related to investment, saving, and 401(k) participation. Bernheim et al. (2011) estimate that the median cost of deviating from the default 401(k) contribution rate exceeds 5.5 percent of income (e.g., approximately $2,200 for a worker earning $40,000).

The remainder of our paper proceeds as follows: in Section 2, we describe the CUNY system. Section 3 outlines a simple conceptual framework allowing for discontinuous borrowing costs, which generates testable predictions for how borrowing and attainment will respond to grant aid in the presence of a fixed cost. We describe our data and sample in Section 4. In Section 5, we discuss our empirical approach, while in Section 6, we present reduced form estimates of the impact Pell Grant aid on student loan aid and educational attainment. In Section 7, we characterize the fixed cost CUNY students incur when borrowing and investigate factors contributing to this cost. Section 8 concludes.

2 The CUNY System and Need-Based Student Aid

The City University of New York (CUNY) is the largest urban public university system in the country, encompassing 17 two- and four-year colleges that serve over 250,000 undergraduate students in a given year. CUNY institutions have low tuition and operate in a state with generous need-based grant aid.[6] A substantial portion of CUNY undergraduates also receive federal grant aid. For example, 81 percent of the 2009 fall cohort of first-time freshmen students received a Pell Grant. Similar to other urban public institutions, CUNY schools have low retention and graduation rates. Among first-time freshmen who enrolled in fall 2006, only 15 percent of students pursuing an associate's degree graduated in four years and only 41 percent of students in a bachelor's degree program graduated within six years.

A centralized application system determines eligibility for federal need-based financial aid. To apply for federal aid, current and prospective students must submit a Free Application for Federal Student Aid (FAFSA) to the U.S. Department of Education every academic year. FAFSA inputs include a detailed set of 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 expected family contribution (EFC) using a complicated, non-linear function of these inputs. Eligibility for Pell Grant aid, subsidized federal student loans, and campus-based aid (e.g., work-study) are determined by a student's EFC and cost of attendance (COA), which includes tuition, fees, and estimated living expenses.[7]

For most students, Pell Grant aid is solely determined by EFC.[8] Students with EFC below a set threshold are eligible to receive the minimum Pell Grant award.[9] Every \$1 decrease in EFC leads to a \$1 increase in (statutory) Pell Grant aid, up to the maximum Pell Grant award.[10]

Low- and middle-income students in New York received \$920 million of grant aid through the state's Tuition Assistance Program (TAP) in 2012.[11] New York State residents must complete a supplemental application for the TAP program, as TAP aid depends on New York State taxable income, which cannot be calculated from FAFSA inputs alone. TAP provides grants to students much higher in the income distribution

[6] Nominal tuition at CUNY four-year schools was \$4000 per year in the 2006-07 through 2008-09 academic years, \$4600 per year in 2009-10, and \$5130 per year in 2010-11. Two-year schools charged full-time students \$2800 in tuition in the 2006-07 through 2008-09 academic years, \$3150 in 2009-10, and \$3600 in 2010-11. Over this period, nominal fees at four-year CUNY schools ranged from \$252 to \$477 per year, while two-year schools charged \$268 to \$355 per year in fees.

[7] Allowable living expenses include the cost of books and supplies, room and board, transportation expenses, miscellaneous personal expenses, and dependent care, when applicable. Within institutions, students within the same broad category (e.g., full-time freshmen living off campus) are all considered to have the sample COA, even if individual living expenses may vary substantially across individuals within a given group.

[8] As long as a student's COA is greater than her statutory Pell Grant, Pell Grant aid only depends on EFC. For most students, this constraint is not binding. The lowest COA faced by full-time, full-year CUNY students was \$8,700 in 2007-08, \$8,800 in 2008-09, and \$9,300 in 2009-10. In comparison, the maximum Pell Grant award was \$4310 in 2007-08, \$4732 in 2008-09, and \$5350 in 2009-10.

[9] The minimum Pell Grant award was \$400 during the 2006-07 and 2007-08 academic years, increased to \$890 in 2008-09 and \$976 during 2009-10, and fell to \$555 in 2010-11.

[10] The maximum Pell Grant award increased every year between 2006-07 and 2010-11, from \$4,050 to \$5,500.

[11] See the National Association of State Student Grant and Aid Programs State Data Quick Check (available at: http://www.nassgap.org/survey/state_data_check.asp).

than the Pell Grant Program - up to $80,000 in New York State taxable income for dependent students.[12]

In addition to federal and state grant aid, CUNY students are eligible to borrow through the federal Direct Loan Program.[13] The terms of federal loan aid depend on a student's course load, tenure, and unmet need. Specifically, a student's unmet need, equal to the total cost of attendance (tuition, fees, and a cost of living allowance) minus EFC and grants, determines her eligibility for subsidized federal loans.[14] First-year students are eligible for subsidized loan aid equal to the lesser of remaining need and $3,500.[15] Dependent first-year students can borrow an additional $2,000 in unsubsidized loans while independent students can borrow an additional $6,000.[16] All students are eligible for unsubsidized loans and even students that do not qualify for subsidized loan aid can still borrow up to the overall maximum in unsubsidized loans (currently, $5,500 for first-year dependent students and $9,500 for first-year independent students). Subsidized loans do not accrue interest until six months after a student leaves school; after this period, students face an interest rate of between 3.4 and 6.8 percent, depending on the year in which the loan was disbursed. The cohorts of students we examine could borrow unsubsidized federal loans at an interest rate of 6.8 percent.[17] Despite low tuition and generous state grant aid, most CUNY students remain eligible to borrow the maximum allowed subsidized federal loans.[18]

The timing of the school and financial aid application processes lends credibility to the use of the Pell Grant formula as a quasi-experiment for estimating effects of grant aid on borrowing and educational investment. Prospective students generally apply to CUNY schools in advance of completing a FAFSA. CUNY schools admit prospective students on a rolling basis, but students must submit an application by February 1st to be guaranteed consideration. Prospective students list up to six two- or four-year colleges within the system they would like to attend, in order of preference, as well as their planned attendance intensity (i.e.,

[12] In the years we examine, the maximum TAP award equals the lesser of $5,000 and tuition and fees.

[13] Prior to 2010, schools participated in one of two parallel federal lending programs: the William D. Ford Federal Direct Loan Program and the Federal Family Education Loan (FFEL) Program, through which the federal government guaranteed loans originated by private lenders. The 2010 Health Care and Education Reconciliation Act abolished the FFEL program. However, since CUNY schools participated in Direct Loan Program prior to 2010, the legislation did not affect federal lending to CUNY students.

[14] Cadena and Keys (forthcoming) estimate that eligible students would receive a subsidy from the federal government worth $1500 if they borrowed the maximum allowed subsidized amount for four years.

[15] Prior to fall 2007, first-year, dependent students could borrow a maximum of $2,625 in subsidized federal loans.

[16] Prior to fall 2008, dependent students were not eligible to borrow above the subsidized limit and independent students were allowed to borrow an additional $4,000 in unsubsidized loans. Students who are considered to be in their second year for federal loan eligibility purposes (i.e., those who have accumulated between 30 and 59 credits) with unmet need can borrow up to $4,500 in subsidized loans ($3,500 prior to fall 2007), while students in their third year and above (i.e., those who have accumulated at least 60 credits) who have unmet need can borrow up to $5,500. Regardless of credits accumulated, students in two-year degree programs are never considered to be third year students for federal borrowing purposes. The overall borrowing limits dependent students face are $6,500 in their second year and $7,500 as upper years ($3,500 and $5,500, respectively, prior to fall 2008), while independent students can borrow up to $10,500 in their second year and $12,500 in their third year and beyond ($7,500 and $10,500, respectively, prior to fall 2008). Students are limited in the total amount of federal debt they can incur during their undergraduate education. Dependent students can borrow up to $31,000 overall ($23,000 subsidized) and independent students can borrow up to $57,500 ($23,000 subsidized). See studentaid.ed.gov/types/loans for additional details.

[17] Current federal law caps the interest rate for direct loans at 8.25 percent.

[18] In general, private lenders and some institutions offer student loans. CUNY schools do not offer loans, and we find that no CUNY students borrow through private lenders, most likely due to the superior terms on federal loans.

full-time or part-time). Because the FAFSA requires information on prior-year taxable income, prospective students generally wait to complete the FAFSA until after their family has filed their tax return (at best, early February).[19] Students are notified of their EFC by the Department of Education shortly after submitting a FAFSA but do not learn of their financial aid eligibility until after they have been admitted to a college. Upon admission, the college provides the student with a financial aid package which specifies grant aid (federal, state, and institutional).[20] During the months leading up to the fall semester, the student decides whether to accept the admissions offer and how much (if any) federal loan debt to incur.

Schools must offer students their full federal grant aid entitlement, but they have discretion over federal loan aid packaging (Scott-Clayton 2013). In the CUNY system, the default amount of offered loan aid is \$0. While most other higher education institutions include suggested federal loan awards as part of a student's financial aid package, CUNY institutions require students to submit a separate application and specify both their desired amount of federal loan aid and whether they are willing to take on unsubsidized debt.[21] Approximately one third of the students in our sample attend an institution that provides an online application for federal loans. The remainder of students must submit an application in person to their institution's financial aid office if they wish to borrow.

3 Conceptual Framework

In this section, we outline our model of students' human capital investment decisions, which we tailor to match the key features of federal student loan programs. An individual lives for two periods. In the first period, she chooses schooling s and debt d to maximize lifetime utility, $U = u(c_0) + \beta u(c_1)$, where subscripts indicate the period, $\beta \in (0,1)$ is the time discount factor, and $u(\cdot)$ follows standard assumptions for instantaneous utility (strictly increasing, strictly concave, and twice continuously differentiable). In the first period, the student receives exogenous grants g from the government and has resources equal to her expected family contribution EFC and exogenous income ω, where ω represents the error term in the federal government's estimation of family resources, and can be positive or negative. The student faces costs $C(s)$ associated with her first period educational investment, which encompass both direct costs $C_t(s)$ (e.g., such as tuition and fees) and opportunity costs $C_i(s)$ (e.g., foregone earnings). $C(s)$ is twice continuously differential, with $C_t'(s) \geq 0$, $C'(s) > 0$ and $C''(s) \geq 0$. In the second period, the student receives earnings $w(s)$ where $w' > 0$

[19] Individuals are allowed to estimate their prior year taxable income if they wish to submit the FAFSA before their family's tax return is submitted, and update the FAFSA information at a later date, but few choose to do so.

[20] Appendix Figure A.1 displays a sample of a CUNY financial aid award letter. Grant and loan aid is first used to pay direct costs (tuition and fees), with the student receiving any remaining aid directly.

[21] Appendix Figure A.2 displays a sample of the additional loan application required by Hunter College.

and $w'' \leq 0$.[22]

Borrowing is subject to multiple interest rates and potential constraints. The student can borrow an amount d, which can be less than zero if the student prefers to save. The gross market interest rate is $R_m < \frac{1}{\beta}$, but the government subsidizes some student loans by charging the rate $R_s < R_m$.[23] The student receives the subsidized interest rate on all loans up to a limiting amount $d_s^{max} = \min\left\{\bar{d}, C_t(s) - g - EFC\right\}$, where $\bar{d}$ is a constant. This formulation captures the structure of the federal subsidized Direct Loan Program, which can be used to cover "unmet need", represented by $C_t(s) - g - EFC$, up to a fixed limit $\bar{d}$. Additionally, the student can borrow up to the overall federal loan limit $\bar{\bar{d}} > d_s^{max}$, where loans in excess of d_s^{max} are subject to the market interest rate.

The student also pays a fixed borrowing cost γ if she chooses any $d > 0$, which represents discrete monetary, time, and psychic costs of incurring debt.[24] For notational convenience, we define indicator functions $\kappa_0 = \mathbf{1}\{d > 0\}$ (incurring positive debt), $\kappa_s = \mathbf{1}\{d > d_s^{max}\}$ (incurring positive unsubsidized debt), and $\xi = \mathbf{1}\left\{C_t(s) - g - EFC < \bar{d}\right\} = \mathbf{1}\{d_s^{max} = C_t(s) - g - EFC\}$ (being bound by the endogenous subsidized borrowing limit) to distinguish between cases.

The student faces budget constraints $c_0 \leq \omega + EFC + g + d - C(s) - \gamma \cdot \kappa_0$ in the first period and $c_1 \leq w(s) - R_s d - \kappa_s (R_m - R_s)\left(d - \bar{d} - \xi\left(C_t(s) - g - EFC - \bar{d}\right)\right)$ in the second period.[25] Assigning the variable λ for the Lagrange multiplier on the maximum-loan constraint, the student solves:

$$\max_{s,d} \{u(\omega + EFC + g + d - C(s) - \gamma \cdot \kappa_0) +$$

$$\beta u\left(w(s) - R_s d - \kappa_s (R_m - R_s)\left(d - \bar{d} - \xi\left(C_t(s) - g - EFC - \bar{d}\right)\right)\right) + \lambda\left(\bar{\bar{d}} - d\right)\Big\}$$

Optimal schooling s^* and debt d^* will satisfy some combination of the first order conditions:

$$u'(c_0) = \beta\left(R_s + \kappa_s (R_m - R_s)\right) u'(c_1) + \lambda \tag{1}$$

[22]We could also allow for heterogeneous costs of schooling effort by letting s enter directly into the period utility functions, as in Cameron and Taber (2004), or by allowing ability to vary across students, as in Lochner and Monge-Naranjo (2011), and our model would yield similar predictions.

[23]In practice, if students were able to earn R_m on their savings, all students should either chose not to borrow, or borrow at or above the subsidized limit. This is because for subsidized loans, students can borrow at R_s and earn $R_m > R_s$ by saving. However, in the years we examine, market interest rates were quite low and students faced a 1 percent origination fee on all loans, resulting in R_s being approximately equal to the market rate. While the interest rate on unsubsidized debt was higher than the market rate in our setting, we only include two terms for gross interest rates, rather than a third term representing the market rate for savings - omitting this additional term does not affect our predictions.

[24]Students pay an origination fee when taking out federal loan aid, but this fee is continuous in the amount borrowed (i.e., 1 percent) and thus, would not represent the fixed cost we model.

[25]We assume the regularity condition $w''(s) \leq -R_m C_t''(s)$ for all s to ensure global concavity of the problem. We deem this condition reasonable because direct costs are linear or concave in schooling, depending on a student's course load: tuition is linear in credits attempted for part-time students, while full-time students (attempting 12 to 18 credits) are charged a flat rate. Additionally, we show in Appendix B that a weaker condition would suffice.

$$C'(s)\,u'(c_0) = \beta\left(w'(s) - \xi\kappa_s\left(R_m - R_s\right)C_t'(s)\right)u'(c_1) \tag{2}$$

$$d = \bar{\bar{d}} \tag{3}$$

Which subset of the first-order conditions applies depends on which case the student falls into. For example, if the maximum loan constraint is not binding ($\lambda = 0$), the student's remaining need is greater than the subsidized loan limit ($\xi = 0$), and optimal borrowing is nonzero ($d^* \neq 0$) then conditions (1) and (2) hold, implying that $C'(s^*) = \left(R_s + \kappa_s\left(R_m - R_s\right)\right)^{-1} w'(s^*)$. In such cases, s^* equates the present discounted values of the marginal costs and benefits of schooling. Optimal schooling does not depend on income or consumption in either period, implying that schooling will not respond to a marginal increase in grant aid. This result is standard: students who not do not face borrowing constraints will not increase their schooling in response to a marginal increase in grant aid.

For a given level of EFC, students can be ordered in terms of additional resources ω. A partition of this spectrum defines the different cases a student may fall into, which we label groups A through F. The chart below summarizes students' choices of debt and responses to grant aid in each potential case. Group A is made up of students with resources great enough that they choose to save (i.e., $d^* < 0$). Group F describes students who have so few resources that they would prefer to borrow more than the maximum allowable government loan $\bar{\bar{d}}$ but cannot. For groups between these extreme cases, the optimal level of debt is weakly decreasing in resources.[26] As long as $\gamma > 0$, there will be some minimum level of debt that students are unwilling to take on, which we denote as $\underline{d}$.

Optimal Borrowing and Educational Investment Decisions by Level of Exogenous Resources

Group	A	B	B/C Switchers	C	D	E	F
d^*	$(-\infty, 0)$	0		$(\underline{d}, d_s^{max})$	d_s^{max}	$\left(d_s^{max}, \bar{\bar{d}}\right)$	$\bar{\bar{d}}$
$\frac{\partial d^*}{\partial g}$	$(-1, 0)$	0	$\frac{\Delta d^*}{\Delta g} = \frac{0-\underline{d}}{\Delta g} < 0$	$(-1, 0)$	$\xi\left(\frac{\partial s^*}{\partial g}C_t'(s^*) - 1\right)$	$(-1, 0)$	0
$\frac{\partial s^*}{\partial g}$	0	$(0, \infty)$	$\frac{\Delta s^*}{\Delta g} = \frac{s_0 - \underline{s}}{\Delta g} < 0$	0	$(0, \infty)$	0	$(0, \infty)$

Notes: Groups are listed in decreasing order of exogenous resources ω, where group A has the highest resources and group F has the lowest resources. Observed debt is bounded from below by 0 and $d^* < 0$ implies saving.

The above table displays categories of students according to their optimal debt level and schooling and borrowing responses to grants. Though we distinguish six distinct groups of students, the groups fall into two general types: those choosing corner solutions for debt – who we label "threshold borrowers" – and those choosing interior solutions for debt. Groups A, C, and E choose interior levels of debt, and the amount they borrow therefore responds to the amount of grant aid they receive. Grant aid does not increase the

[26]See Appendix B for proofs.

educational attainment of students in these three groups. Threshold borrowers, however, arrive at a corner solution for borrowing due to the presence of fixed costs (Group B), kinks in the interest rate schedule (Group D), or credit constraints (Group F).

Panel A of Figure 1 displays the borrowing and consumption choices of Groups B, C, and D members on along the budget constraint. Members of Group A (not shown) locate to the left of the discontinuity in the budget set caused by the fixed cost, while individuals in Group B arrive at a corner solution and neither borrow nor save. Likewise, Group D members borrow at the subsidized maximum, arriving at a corner solution caused by the interest rate kink, and Group F members (not shown) borrow at the federal maximum, represented by the far right discontinuity in the budget constraint. Students in Group C locate between the discontinuity and the interest rate kink, while those in Group E (not shown) locate between the interest rate kink and discontinuity caused by the federal borrowing limit.

The remainder of Figure 1 provides an illustration of the impact of Pell Grant aid on students' borrowing decisions. Students in Group B remain at their borrowing thresholds when grants increase slightly but complete more schooling in order to raise the ratio of future income to current income (Panel B). Members of Groups D and F, follow a similar response.[27] Responses within and between these groups are all continuous except for students switching between Groups B and C (Panel C). Students whose optimal debt is close to $\underline{d}$ may be induced to switch to $d^* = 0$ by small increases in grant aid, Δg. Those who would have taken small loans in the absence of the fixed cost will instead choose not to borrow, which in turn, leads to a reduction in educational attainment. This unintended consequence of grant aid leads to our first and third empirical predictions described below.

3.1 Empirical predictions

Our framework generates three key predictions concerning how overall borrowing and educational investment respond to changes in grant aid in the presence of a fixed cost:

1. *If the fixed cost of borrowing $\gamma > 0$ then $\underline{d} > 0$, and an increase in grant aid may lead to a greater than \$1 for \$1 reduction in loans for borrowers.* This result allows for crowd-out to exceed 100 percent. If students have loans close to $\underline{d}$, a small increase in grants will cause a discrete drop in (observed) borrowing to zero. With no fixed borrowing cost, the amount of crowd-out is strictly bounded above by 100 percent because $\frac{\partial d^*}{\partial g}$ is bounded from below by -1 for all groups and there would be no groups between which there would be a discontinuity in optimal borrowing.

[27] Students remain at their respective borrowing thresholds by keeping debt constant, except in the case of students in Group D for whom unmet need is less than the exogenous limit on subsidized loans ($\xi = 1$). For these students, grants reduce unmet need and consequently the amount they can borrow at the subsidized rate. These students adjust loans so as to remain at the kink but otherwise behave like other threshold borrowers, increasing schooling as grant aid rises.

2. *Grants only increase threshold borrowers' educational attainment.* Students facing a straightforward borrowing choice (Groups A, C, and E) choose the level of schooling that equates current marginal cost with discounted future marginal benefit and then use debt to smooth income between periods (e.g., Figure 1, Panel D). An increase in grant aid has no impact on educational attainment; it only induces these students to borrow less. On the other hand, threshold borrowers (Groups B, D, and F) are limited in their ability to offset small changes in grant aid by altering their borrowing. Only these groups respond to grant aid by increasing schooling (e.g., Figure 1, Panel B). Finally, students induced to switch from Group C to Group B will respond to a marginal increase in grant aid by reducing schooling (e.g., Figure 1, Panel C).

3. *Grants decrease educational attainment of students whose optimal debt level drops from (weakly) above $\underline{d}$ to a positive amount below $\underline{d}$.* Students whose optimal borrowing after grant aid falls below $\underline{d}$ will no longer be willing to pay the fixed cost of borrowing. Foregoing loans reduces current consumption but raises future consumption, causing these students to invest less in education in order to shift consumption to the present.

4 Data and Sample

In order to take advantage of the nonlinearities in the Pell Grant Program's schedule, we need data that contains information on the underlying assignment variable (EFC), our outcomes of interest (borrowing and educational investment), and a sufficient number of observations to focus on the outcomes of students on either side of the discontinuities in the Pell Grant formula. We use administrative data from the CUNY system that contains the universe of students from multiple cohorts. This data provides extensive information on students' EFC, student grant and loan aid, and measures of educational attainment (GPA, and credits attempted and earned for semesters between entry and spring 2011).

Our primary sample includes eight cohorts of first-time, degree-seeking freshmen who entered a CUNY institution in the fall of the 2004-05 through 2010-11 academic years (hereafter 2005 through 2011 academic years). Unfortunately, we only observe students' FAFSA information (most importantly EFC) between 2007 and 2011.[28] We observe students in their first three years of attendance and differentiate students by entry cohort and level, where level corresponds to years since college entry. We restrict our sample to only include US citizens or permanent residents.[29] Finally, we eliminate students with with an EFC more than $4,000

[28] Thus, we observe up to three years of financial aid outcomes for the 2007 through 2009 cohorts, two years for the 2006 and 2010 cohorts, and one year for the 2005 and 2011 cohorts.

[29] Non-citizens that are not permanent residents are ineligible for most federal and state grant aid and make up less than 1 percent of students in these cohorts.

from the threshold for Pell Grant eligibility. This window excludes students with an EFC equal to zero, who are eligible for the maximum Pell Grant award.[30]

Table 1 displays the characteristics of students in their first year by Pell Grant eligibility. Pell Grant eligible students receive more TAP and other grant aid (including aid from smaller state and federal grant programs, as well as institutional aid) than ineligible students, while ineligible students take on greater debt. On average, both eligible and ineligible students borrow at low rates; only 12 percent of the sample takes on any debt in their first year, despite having substantial need and eligibility for subsidized loans. Less than 1 percent of our sample exhausts their total federal loan eligibility in their first year. Pell-ineligible students are more likely to borrow, with 24 percent taking on some debt. Finally, Pell Grant eligible students have different demographic characteristics than ineligible students - they are more likely to be nonwhite, have lower SAT scores, and are less likely to have a college educated parent. These differences in observable characteristics between Pell Grant recipient students and ineligible students motivate our use of RD and RK designs to identify the causal impact of grant aid on student outcomes.

4.1 Are CUNY Pell Grant recipients representative of the national population?

In Table 2, we the compare the demographic characteristics, cost of attendance, and financial aid for the 2008 cohort of first-year, degree-seeking, CUNY Pell Grant recipients to a nationally representative sample using data from the 2008 National Postsecondary Student Aid Study (NPSAS).[31] We compare CUNY students to both the full NPSAS sample and to public school NPSAS students.[32]

CUNY Pell Grant recipients have greater need than the average Pell Grant recipient enrolled in a public institution, and slightly higher, but comparable need relative to Pell Grant recipients enrolled in public and private schools (Table 2, Panel A). CUNY students also receive more grant aid. After taking into account federal, state, and institutional grant aid, CUNY students have around $5,000 in unmet need compared to $5,700 for the full nationally representative sample and approximately $3,700 for public school students.

CUNY Pell Grant recipients borrow at much lower rates than the average Pell Grant recipient, despite having similar levels of remaining need after accounting for grant aid and EFC. While on average, 36 percent

[30]For the 2007 through 2009 academic years, dependent students and independent students with children would automatically receive a $0 EFC if their family income fell below $20,000 and their parents either received means tested benefits during the year or were eligible to file a simplified tax return (indicating low assets). In 2010, the income limit was raised to $30,000. See http://www.ifap.ed.gov/eannouncements/attachments/0708EFCFormulaGuide.pdf and http://www.ifap.ed.gov/efcformulaguide/attachments/111408EFCFormulaGuide0910.pdf for further details.

[31]The NPSAS is a a nationally representative, restricted-use, repeated cross-section of college students. A stratified random sample of Title IV-eligible institutions is first drawn, and from these institutions, degree-seeking students are selected into the NPSAS. The Department of Education's National Center for Education Statistics (NCES) collects NPSAS data on a three to four year cycle, with the last publicly available data covering the 2008 academic year. I use the publicly available NCES Data Analysis System (DAS) to generate aggregate statistics from this underlying sample (see http://nces.ed.gov/das/index.asp for further details).

[32]In 2008, 64 percent of all Pell Grant recipients were enrolled in public schools (U.S. Department of Education 2009).

of public school Pell Grant recipients borrow, only 4 percent of CUNY students incur any student loan debt in their first year.[33] CUNY students entirely avoid private loans, while 25 percent of college students nationwide and 12 percent of public school students take on private student loan debt.

In terms of their demographic characteristics, on average, CUNY Pell Grant recipients are younger, more likely to be classified as dependent students, more likely to be nonwhite, and more likely to have parents who did not attend college (Panel B). CUNY students' SAT performance is comparable to that of the average Pell Grant recipient. Finally, CUNY Pell Grant recipients are more likely to be first- or second-generation immigrants, reflecting the fact that the majority of CUNY students attended New York City public schools. Burdman (2005) shows that first-generation college students are more likely to voice aversion to taking on student loan debt; thus, we examine whether our main estimates vary across a number of pre-determined characteristics, including dependency, parental education, and immigrant status.

5 Empirical Framework

We use the variation induced by the kink and discontinuity in the Pell Grant Program's formula to identify the impact of Pell Grant aid on educational investment. The kink occurs where the slope of the statutory $Pell\,(EFC)$ schedule changes from 0 to -1, while the discontinuity is driven by the increase in Pell Grant aid from \$0 to the minimum Pell Grant award at the eligibility threshold. Since the eligibility threshold occurs at different EFC values in different years, we standardize our measure of EFC to represent distance from the year-specific threshold. Figure 2 displays the empirical distribution of Pell Grant aid, pooling first, second, and third year students.[34]

Let $Y = \tau Pell + g\,(EFC) + U$ represent the causal relationship between educational investment, Y, and Pell Grant aid, $Pell = Pell\,(EFC)$, where U is a random vector of unobservable, predetermined characteristics. The required identifying assumptions for the RK design are: (1) the direct marginal impact of EFC on Y is continuous (e.g., around the eligibility threshold, there are no discontinuities in the direct relationship between EFC and Y) and (2) the conditional density of EFC (with respect to U) is continuously differentiable at the threshold for Pell Grant eligibility (Card et al. 2012). These assumptions encompass those required for identification using the RD design (Hahn et al. 2001). As long as the relationship between un-

[33] In general, CUNY students borrow at much lower rates than other public college students. For instance, 35 percent of 2008 full-time degree seeking students attending four-year public schools received federal loan aid while only 5 percent of full-time, bachelor's degree seeking CUNY students took out federal loans in 2008 (National Center for Education Statistics 2013). Similarly, 5 percent of 2008 full-time associate's degree seeking CUNY students took out federal loans while 19 percent of full-time, degree-seeking two-year students borrowed. Finally, Cadena and Keys (forthcoming) examine a nationally representative sample of full-time four-year students attending public and private nonprofit institutions, and estimate that 83 percent of students eligible for subsidized borrowing take advantage of federal loan aid. In comparison, only 8 percent of full-time, bachelor's degree-seeking CUNY students that are eligible for subsidized borrowing take out student loans.

[34] Appendix Figure A.3 displays the empirical distribution of Pell Grant aid by level of attendance.

observable factors and EFC evolves continuously across the Pell Grant eligibility threshold, the RK design approximates random assignment in the neighborhood of the kink. Additionally, as in the case of 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.

If these conditions hold, then both the RK estimator, τ_{RK}, and the RD estimator, τ_{RD}, will identify the causal impact of Pell Grant aid:

$$\tau_{RK} = \frac{\lim\limits_{\varepsilon\uparrow 0}\left[\frac{\partial Y|EFC=efc_0+\varepsilon}{\partial efc}\right] - \lim\limits_{\varepsilon\downarrow 0}\left[\frac{\partial Y|EFC=efc_0+\varepsilon}{\partial efc}\right]}{\lim\limits_{\varepsilon\uparrow 0}\left[\frac{\partial Pell|EFC=efc_0+\varepsilon}{\partial efc}\right] - \lim\limits_{\varepsilon\downarrow 0}\left[\frac{\partial Pell|EFC=efc_0+\varepsilon}{\partial efc}\right]} = \tau \tag{4}$$

$$\tau_{RD} = \frac{\lim\limits_{\varepsilon\uparrow 0}[Y|EFC = efc_0+\varepsilon] - \lim\limits_{\varepsilon\downarrow 0}[Y|EFC = efc_0+\varepsilon]}{\lim\limits_{\varepsilon\uparrow 0}[Pell|EFC = efc_0+\varepsilon] - \lim\limits_{\varepsilon\downarrow 0}[Pell|EFC = efc_0+\varepsilon]} = \tau \tag{5}$$

Where efc_0 represents the Pell Grant eligibility threshold. Since not all students complete a full year of college, EFC will imperfectly predict students' Pell Grant aid. Therefore, in practice, our estimation strategy involves fuzzy RD/RK. Specifically, we use an instrumental variables approach to estimate τ_{RK} and τ_{RD}. Since the eligibility threshold changes as the size of the maximum Pell award increases, we first create a standardized measure of the distance a student's EFC falls from the Pell Grant eligibility threshold: $\widetilde{EFC}_{it} = EFC_{it} - efc_{0t}$.

Consider the following first stage and reduced form equations, where i indicates students, t indicates year, c indicates cohorts, and s indicates colleges, $f(\cdot)$ and $g(\cdot)$ are flexible functions of $\widetilde{EFC}$ that we allow to vary depending on the side of the eligibility threshold on which a student falls, and $\mathbf{X}$ is a vector of demographic characteristics:

$$Pell_{ist} = f\left(\widetilde{EFC}_{it}\right) + \beta_1 \mathbf{1}\left[\widetilde{EFC}_{it} < 0\right] + \beta_2 \widetilde{EFC}_{it} \times \mathbf{1}\left[\widetilde{EFC}_{it} < 0\right] + \boldsymbol{\eta}\mathbf{X_{it}} + \delta_s + \delta_c + \nu_{ist} \tag{6}$$

$$Y_{ist} = g\left(\widetilde{EFC}_{it}\right) + \pi_1 \mathbf{1}\left[\widetilde{EFC}_{it} < 0\right] + \pi_2 \widetilde{EFC}_{it} \times \mathbf{1}\left[\widetilde{EFC}_{it} < 0\right] + \boldsymbol{\phi}\mathbf{X_{it}} + \alpha_s + \alpha_c + \epsilon_{ist} \tag{7}$$

In this framework, $\hat{\tau}_{RK} = \frac{\hat{\pi}_2}{\hat{\beta}_2}$ and $\hat{\tau}_{RD} = \frac{\hat{\pi}_1}{\hat{\beta}_1}$. In practice, we use both the kink and the discontinuity for identification and provide separate estimates by years since college entry.[35]

Table 3 displays first stage estimates of the impact of the kink and discontinuity on Pell Grant aid by

[35] Dong (2013) shows that with locally constant treatment effects, the combined RD/RK estimator $\frac{\hat{\pi}_1+w\hat{\pi}_2}{\hat{\beta}_1+w\hat{\beta}_2} = \tau$, where weights w are based on the relative strength of the first stage relationship.

student level, and pooling across all students, where $f(\cdot)$ and $g(\cdot)$ are quadratic functions of $\widetilde{EFC}$, estimated separately on either side of the eligibility threshold. On average, first-year students that are barely-eligible for Pell Grants aid experience an approximately \$390 increase in Pell Grant aid, and for every dollar decrease in EFC, their Pell Grant increases by approximately \$0.76. Point estimates for the set of second and third year students are similar.

We are also interested in estimating whether Pell Grant aid has persistent impacts on educational investment. To do so, we regress the period $t+n$ outcome on Pell Grant aid received in period t, and estimate 2SLS models where the second stage takes the form:

$$Y_{ist} = \tau_n \widehat{Pell}_{it-n} + g_n\left(\widetilde{EFC}_{it-n}\right) + \varsigma \mathbf{X_{it}} + \varphi_s + \varphi_c + \varepsilon_{istn} \tag{8}$$

Here, τ_n represents the impact of \$1000 additional Pell Grant aid in period $t-n$ on the period t outcome, *vis-à-vis* all other intermediate outcomes affected by Pell Grant aid (including future disbursements of grants). Both the kink and discontinuity in period $t-n$ serve as excluded instruments for $Pell_{it-n}$.[36] As shown in Panel B of Table 3, an additional dollar of Pell Grant aid in a student's first year leads to a dollar increase in cumulative Pell Grant aid two and three years after entry.

5.1 Evaluating the RD and RK identifying assumptions

We evaluate the RD/RK identifying assumptions by examining the density of first-year CUNY students on either side of the Pell Grant eligibility threshold and the distribution of observable characteristics, including gender, race, family adjusted gross income (AGI), average math and verbal SAT scores (when available), parental education, and dependency status. As shown in Figure 3, the level and slope of the density function are continuous through the threshold.[37] We find no evidence of a discontinuous change in the level or slope of the density or in observable characteristics (Figure 4).[38]

Examining the density of first-year students around the Pell Grant eligibility also allows for an implicit test of whether Pell Grant generosity affects enrollment (within the CUNY system), where additional mass to the left of the threshold would suggest that Pell Grant aid increases the probability of enrollment. We estimate equation (7), where the dependent variable is the number of students in a given \$200 $\widetilde{EFC}$ bin,

[36] This is a version of the ITT estimator proposed by Cellini et al. (2010).

[37] Appendix FigureA.4 displays the density of second and third year CUNY students in our sample.

[38] Appendix Table A.1 contains corresponding point estimates from regressions of predetemined characteristics on the kink, discontinuity, a quadratic in $\widetilde{EFC}$ allowed to vary on either side of the Pell Grant eligibility threshold, degree program fixed effects, and school by year fixed effects. With the exception of family AGI, these point estimates are small and insignificant. However, we do find a statistically significant decrease in AGI at the Pell Grant eligibility threshold of approximately \$1,150 among first year students and larger for second and third year students (\$2,669 and \$2,163, respectively). This relationship could arise from the relationship between AGI and EFC, and when we include higher order polynomials in $\widetilde{EFC}$, the decrease in AGI at the threshold is no longer significant.

and choose the degree of polynomial in $\widetilde{EFC}$ that minimizes the Aikaike Information Criterion (AIC). For first-year students, we estimate an insignificant reduction in the number of students to the left of threshold, with our 95 percent confidence interval containing both a 124 student decrease in enrollment and a 46 student increase in enrollment. Scaling these bounds by the number of students immediately to the right of the threshold (approximately 725), we can rule out changes in enrollment due to Pell Grant eligibility that exceed a 15 percent reduction and a 7 percent increase.[39]

6 The Impact of Pell Grant Aid on Borrowing and Attainment

Our model suggests that Pell Grant aid will reduce unconstrained students' borrowing. Predicted effects on educational attainment vary, with "threshold borrowers" increasing schooling, unconstrained students not altering their schooling, and students who stop borrowing in response to additional Pell dollars experiencing a reduction in attainment. In this section, we first present graphical evidence of the reduced form impacts of Pell Grant eligibility and generosity on borrowing and then present estimates from our parametric specification.

6.1 Pell Grant aid reduces borrowing

Figure 5 displays mean student loan aid by distance from the Pell Grant eligibility threshold for first year students.[40] Average loan aid falls discontinuously at the Pell Grant eligibility threshold, and the relationship between borrowing and EFC changes discontinuously, indicating that (on average) students reduce borrowing upon receiving additional grant aid.[41] These impacts are driven by a reduction in the probability of any borrowing at the threshold, as well as a reduction in the size of loans conditional on taking on any debt (Figure 6).

To quantify the contemporaneous impact of Pell Grant aid on borrowing, we estimate equation (7), generating separate estimates by years since college entry (Table 4). Panel A presents reduced form impacts of Pell Grant eligibility and generosity on student loan aid. Panel B displays 2SLS estimates of the impact of Pell Grant aid on debt using both the kink and discontinuity as instruments for Pell Grant aid. An additional dollar of Pell Grant aid induces first-year students to reduce borrowing by approximately \$0.43. Second- and third-year students respond to an additional dollar of Pell Grant aid by forgoing \$0.34 and

[39] Unfortunately, we currently do not observe the universe of applicants to CUNY schools. Once we obtain this data, we will be able to construct a more denitive test of the impact of Pell Grant aid on enrollment (conditional on applying for college).

[40] We present corresponding results for second and third year students in Appendix A and report 2SLS point estimates separately by level when we present results from our parametric specification.

[41] This reduction primarily comes from a fall in subsidized loans (Appendix Figure A.6), likely due to the fact that few borrowers take on unsubsidized debt.

\$0.72, respectively.[42]

Panel C displays estimates of the impact of an additional dollar of Pell Grant aid in a student's first year on cumulative student loan debt two and three years after entry, regardless of whether a student persists or leaves college. Pell Grant aid has persistent effects on borrowing and we estimate that an additional \$1000 of Pell Grant aid in a student's first year reduces cumulative debt by close to \$600 three years after entry, a 57 percent decrease from the sample mean.

Consistent with our fixed-cost borrowing model, grant aid crowd-out of loans exceeds 100 percent among borrowers. We define the "latent probability of borrowing" as the borrowing rate among Pell Grant-ineligible students near the eligibility threshold. Under the assumption that these students represent a valid counterfactual for the outcomes of students barely eligible for Pell Grant aid, we can scale our estimates of the impact of Pell Grant aid on borrowing by this probability to determine crowd-out among borrowers and would-be borrowers. For instance, fewer than 24 percent of Pell-ineligible first-year students borrow, yet \$1 increase in Pell Grant aid reduces average loan aid by \$0.43, suggesting crowd-out exceeding to \$1.80 among borrowers and would-be borrowers. We jointly estimating the overall impact of Pell Grant aid on borrowing and latent probability of borrowing (using only the sample of Pell ineligible students). We then scale our 2SLS estimates by the latent probability of borrowing and generate standard errors using a block bootstrap that allows for clustering at the institution by year level; results are displayed in Panel D of Table 4. Among borrowers and would-be borrowers, an additional dollar of Pell Grant aid crowds out between \$1.40 and \$2.43 in student loan aid. Among first and third year students, we can reject the hypothesis that crowd-out for borrowers falls below 100 percent at the 99 percent level.

Finally, we examine the impact of Pell Grant aid on other sources of grant aid and total financial aid (Appendix Table A.3). First, we examine impacts on grant aid from the New York State Tuition Assistance Program (TAP). A student's TAP grant is determined by her New York State Taxable Income, which does not have a one-to-one correspondence with EFC. Thus, this exercise serves as a placebo test since we should not expect to find a relationship between two sources of aid that are independently determined. As expected, we find no evidence of a relationship between TAP and Pell Grant aid. We find a positive relationship between Pell Grant aid and aid from other grants (including institutional, federal, and non-TAP New York State aid) for first- and second-year students, although this relationship is only statistically signicant among first-year students, who receive an additional \$0.08 in other grant aid for every dollar of Pell Grant aid.[43] Finally, we

[42] Appendix Table A.2 displays estimated impacts on subsidized borrowing and unsubsidized borrowing separately.

[43] Some sources of grant aid are directly tied to Pell Grant eligibility (e.g., federal Academic Competitiveness Grant aid) while others may be endogenously chosen by the institution after Pell Grant aid is revealed (e.g., Turner 2013). Unfortunately, we cannot separate out the category of "other grant aid" into aid from specific sources, which likely include federal grants (e.g., Academic Competitiveness Grant, Supplemental Educational Opportunity Grant) and institutional grant aid. However, we estimate that over 40 percent of the increase in other grant aid at the Pell Grant eligibility threshold can be explained by the federal Academic Competitiveness Grant, which provided an average of \$133 in additional grant aid to first and second

quantify the impact of Pell Grant aid on total aid from all sources. On net, a \$1 increase in Pell Grant aid leads to a \$0.79 increase in total aid received by first-year students, a \$0.73 increase in second year students' total aid, and an insignificant insignificant \$0.28 increase in total aid for third-year students.

6.2 Robustness of the estimated impact of Pell Grant aid on borrowing

Before concluding that CUNY students' borrowing decisions are influenced by a fixed cost of taking on debt, we need to rule out the possibility that our estimates are driven by our choice of bandwidth or polynomial in $\widetilde{EFC}$. We estimate 2SLS models in which we focus on first-year students with EFCs within \$3000, \$2000, and \$1000 of the Pell Grant eligibility threshold, and within each window around the eligibility threshold, we allow for up to a fourth degree polynomial in the running variable. For each window, the optimal degree of polynomial in $\widetilde{EFC}$ minimizes the AIC. Finally, we employ the goodness-of-fit test suggested by Lee and Lemieux (2010), by testing the joint significance of \$200 $\widetilde{EFC}$ bin dummies added to our main specification (brackets contain p-values from this test). This exercise also directly tests for discontinuities in borrowing away from the Pell Grant eligibility threshold.

Table 5 displays impacts on first-year students' borrowing (impacts on second- and third-year students' borrowing and cumulative debt are available upon request). Estimates are robust to smaller windows and higher order polynomials. Our point estimates increase in magnitude when we include higher degree polynomials in $\widetilde{EFC}$ or limit our sample to students closer to the Pell Grant eligibility threshold. For instance, when we limit our sample to students with EFCs within \$1000 of the threshold and allow for a cubic in $\widetilde{EFC}$, we estimate that every dollar of Pell Grant aid leads to a \$0.77 reduction in loans, which represents an approximately \$3.20 decrease for borrowers. In fact, when scaled by the percentage of Pell Grant ineligible students who borrow, all but one of the point estimates suggest that crowd-out of borrowing in response to Pell Grant increases exceeds 100 percent.

Table 6 displays results from additional robustness tests. In Panel A, we present separate IV-RD and IV-RK estimates of the impact of Pell Grant aid on borrowing. Point estimates using only the discontinuity as an instrument for Pell Grant are larger in magnitude than estimates obtained from instrumenting with only the kink, but IV-RK estimates still predict crowd-out for borrowers and would-be borrowers that exceeds 100 percent. In Panel B, we take into account the increase in total grant aid that results from a \$1 Pell Grant increase. We want to rule out the fact that our estimates are driven by both an increase in Pell Grant aid and grant aid from other sources. To do so, we estimate (7) but replace the endogenous regressor

year Pell Grant eligible CUNY students that completed a rigorous high school curriculum in 2008, 2009, and 2010 (authors' calculations, available upon request; see http://www2.ed.gov/about/offices/list/ope/ac-smart-families.html for details). The remainder of increase in other grant aid that Pell Grant recipients experience could come from the federal Supplemental Educational Opportunity Grant (SEOG) or institutional aid.

with the sum of Pell Grant aid and other grant aid; results are consistent with those generated by our main specification. In Panel C, we address the concern that increases in Pell Grant aid may mechanically decrease borrowing by reducing some students eligibility for subsidized loans.[44] We show that our main results are robust to limiting our sample to students whose subsidized loan eligibility is not affected by Pell Grant aid, although standard errors grow due to the loss of observations. Finally, in Panel D, we show that estimates from models that exclude all covariates besides the quadratic in $\widetilde{EFC}$ are consistent with our main results.

We also estimate the impact of Pell Grant aid on borrowing via local linear regression (Appendix Table A.4). In Panel A, we use the Imbens and Kalyanaraman (2012) optimal bandwidth. In Panel B, we follow Card et al. (2012) and use the Fan and Gijbels (1996) rule-of-thumb bandwidth, and Panel C uses the bandwidth chosen by the cross-validation proceedure proposed by Ludwig and Miller (2005).[45] In all cases, we use a uniform (rectangular) kernel and cluster standard errors at the institution by year level. We report first-stage, reduced form, and 2SLS estimates (using either the kink, the discontinuity, or both as instruments). In the case of 2SLS specifications, we use the bandwidth chosen for the outcome (rather than the endogenous regressor). In each case, our estimates are less precise but consistent with those obtained from our parametric specification.

6.3 Impacts on educational attainment

When the cost of borrowing is continuous in loan aid, grants increase the attainment of credit-constrained students but do not alter the schooling decisions of students at interior solutions for borrowing. Our model shows that, in the presence of a fixed cost of incurring debt, grant aid has ambiguous impacts on average educational attainment. Grants induce a subset of students to stop borrowing to avoid this fixed cost, leading to a decrease in educational attainment. As a result, the aggregate effect of grants on attainment is ambiguous and likely to depend on the population studied.

Table 7 displays 2SLS estimates of the impact of an additional \$1000 in Pell Grant aid on contemporaneous and longer-run educational outcomes, including persistence (measured by the probability remaining enrolled in the following semester), effort (measured by academic and remedial credits attempted), attainment (measured by academic credits earned), and performance (measured by GPA).[46] Overall, additional Pell Grant aid has small or nonexistent impacts on attainment and performance. We find small, marginally

[44]For instance, increases in Pell Grant aid will directly affect subsidized loan eligibility for students with less than \$3500 in unmet need. Specifically, suppose a student has \$2000 in unmet need, and therefore, is eligible to borrow up to \$2000 in subsidized loans. The discrete increase in Pell Grant aid that occurs at the eligibility threshold, from \$0 to the minimum Pell award, will reduce her eligibility for subsidized loans to \$2000-$minPell$. However, her overall eligibility for student loan aid remains unchanged.

[45]We use the `rdrobust` Stata command to estimate the bandwidth chosen by the Ludwig-Miller cross-validation proceedure (Calonico et al. 2014).

[46]Appendix Figure A.7 displays graphical evidence of the reduced form, contemporaneous relationship between Pell Grant eligibility and generosity and educational attainment, pooling first, second, and third year students.

significant impacts on credits attempted by first-year students, with an additional $1000 of Pell Grant aid inducing students to take an additional 0.7 credits (an approximately 3 percent increase from the mean for Pell Grant ineligible students). This effect does not translate into an increase in academic credits earned.

Ultimately, we are interested in whether Pell Grant aid has longer-run impacts on attainment. The fourth column of Table 7 displays estimates of first-year Pell Grant aid on enrollment, cumulative credits attempted, and cumulative credits earned three years after entry. An additional $1000 of Pell Grant aid in a student's first year leads to an insignificant 0.4 increase in cumulative credits. Furthermore, we can rule out impacts on cumulative credits that are larger than a 3 credit (7 percent) gain three years after entry, suggesting that, on average, Pell Grant aid does little to increase the educational attainment of CUNY students.

Our finding that the average impact of Pell Grant aid on educational attainment is not significantly different from zero is also consistent with heterogeneous treatment effects. Our model predicts that only students arriving at a corner solution for borrowing ("threshold borrowers") will respond to increases in Pell Grant aid by increasing schooling, while those at interior solutions will not respond. Finally, students who cease borrowing due to a binding fixed cost will experience a reduction in educational attainment. We check for heterogeneous treatment effects by estimating effects on the quantiles of cumulative credits earned three years after entry but find no statistically significant point estimates at any quantile (available upon request).

6.4 Heterogeneity

Finally, we test whether the impact of Pell Grant aid on borrowing and attainment varies across students with different demographic characteristics. CUNY students are more likely to be first or second generation immigrants, more likely to be considered dependent students, and are less likely to have a college educated parent. We also test for heterogeneity by students' initial degree program. In Table 8, we present estimates of the impact of Pell Grant aid on borrowing (Panel A) and credits earned (Panel B) by first-year students from fully-interacted models. We test the equality of overall impacts on borrowing and impacts for borrowers and would-be borrowers and display the respective p-values below point estimates. Although we find some evidence of lower crowd-out in some groups (e.g., independent students, BA degree seeking students), point estimates are not statistically distinguishable across any of these dimensions.

We do find some evidence of heterogeneous impacts of Pell Grant aid on attainment. An additional $1000 of Pell Grant aid leads to a 5 credit increase among independent students and we can reject the equality of estimates for dependent and independent students at the 1 percent level. Additionally, Pell Grant aid leads to a marginally significant increase in credits earned for students with a college educated parent, with an additional $1000 of Pell Grant aid leading to a 1 credit increase.

7 Characterizing the Fixed Cost of Borrowing

A fixed cost of borrowing can explain our finding that an additional dollar of grant aid induces some students to reduce student loans by more than a dollar. In the canonical model, a student equates current and future marginal utility of consumption and therefore saves only a portion of the marginal grant dollar for the future by reducing debt. When borrowing entails a fixed cost, however, the receipt of an additional dollar of grant aid may cause a student to switch from borrowing hundreds or thousands of dollars to borrowing nothing. Large shifts in borrowing are possible because there is a range $(0, \underline{d})$ in which the amount of debt that would solve the first-order condition (1) would produce only a small utility gain over zero borrowing and hence would not be worth paying the fixed cost. As a result, few students should borrow in small amounts and we expect crowd-out would be greatest among students who would take-up small positive loans in the absence of Pell Grant aid. We provide evidence for both implications, then outline a strategy for estimating the impact of eliminating the fixed cost on borrowing rates and debt.

As shown in Figure 7, which displays the distribution of loans among first-year borrowers with a subsidized loan limit of $3500, students are unlikely to take up small amounts of debt. The density of loans is generally upward sloping between zero and $2000, as would be the case if students exhibit heterogeneous fixed borrowing costs. These simple histograms, however, do not rule out the possibility that the distribution of desired loan amounts simply does not often take on small positive values.

Estimates of the quantile treatment effects of grant aid on loans reinforce the fixed cost interpretation by showing that the impact of Pell Grant eligibility on borrowing is larger for quantiles corresponding to small positive amounts of debt. Figure 8 provides inverse CDFs of loan amounts for first-year (Panel A) and all students (Panel B) with EFCs within $1000 of Pell Grant eligibility threshold. The vertical distance between the curves provides a reduced-form estimate of the quantile treatment effects of Pell Grant eligibility. In the pooled sample, Pell Grant eligibility does not affect borrowing below the 75nd quantile because three-quarters of students borrow nothing irrespective of their eligibility for Pell Grant aid. Differences in borrowing between eligible and ineligible students are also small at the highest quantiles, but at intermediate quantiles, a Pell Grant of less than $1000 reduces borrowing by close to $2000. The patterns for quantiles in which ineligible students borrow but eligible students do not suggest heterogeneous values of $\underline{d}$ that may reach into the thousands of dollars. These patterns are suggestive, but cannot provide an unbiased estimate of $\underline{d}$ if Pell Grants induce students to switch quantiles (i.e., if the assumption of rank-invariance is violated).

7.1 Model and implementation

To estimate the threshold loan amounts below which students are unwilling to borrow, we employ a maximum likelihood approach. The econometric model is similar in spirit to a Tobit model, but we treat the censoring threshold as a random effect that varies across students.

Student i in year t has latent, desired loans $d_{it}^{*} = \mathbf{X_{it}}\beta + e_{it}$ and borrowing threshold $\underline{d}_i$, where $\underline{d}_i$ is exponentially distributed with density $f(\underline{d}_i, \theta_d) = \xi e^{-\xi \underline{d}_i}$ and $e_{it} \sim G(e_{it}, \theta_e) = N\left(0, \sigma^2\right)$ is normally distributed with cumulative distribution $G(e_{it}, \theta_e)$ and density $g(e_{it}, \theta_e)$. We focus on subsidized loans, which constitute most CUNY borrowing and are utilized before unsubsidized loans, and which are capped by loan limit d_{it}^{max}.

Specification of the model requires an assumption about students' knowledge of their loan limits, d_{it}^{max}. The question that arises is whether a student will borrow if $d_{it}^{max} < \underline{d}_i < d_{it}^{*}$. We consider the two extremes of zero knowledge and perfect knowledge about the loan limit. If student i does not know about her loan limit until after she incurs the fixed borrowing cost, then she will borrow if $d_{it}^{*} \geq \underline{d}_i$, and observed loans will equal $d_{it} = d_{it}^{*} \times \mathbf{1}\left[d_{it}^{*} \geq \underline{d}_i\right]$. On the other hand, if the student knows that her subsidized loans will be capped by d_{it}^{max} before paying the fixed cost, she will only borrow if $\min\left(d_{it}^{*}, d_{it}^{max}\right) \geq \underline{d}_i$, and observed loans will equal $d_{it} = \min\left(d_{it}^{*}, d_{it}^{max}\right) \times \mathbf{1}\left[\min\left(d_{it}^{*}, d_{it}^{max}\right) \geq \underline{d}_i\right]$. Because information about loan limits is likely to vary, we estimate both a known-limits model and an unknown-limits model to obtain bounds for all estimates.

The likelihood of the observed data conditional on parameter values must be specified for each student over each possible value of $\underline{d}_i$ for that student. In the known-limit model, if a student is observed borrowing a strictly positive amount in any year then that student's time-invariant threshold $\underline{d}_i$ must be less in value than the smallest nonzero amount borrowed. Let $\hat{d}_i$ denote the largest possible value of $\underline{d}_i$ for a student who knows the loan limit, where:

$$\hat{d}_i := \begin{cases} \min\limits_t d_{it}\, s.t.\, d_{it} > 0 & if \max\limits_t d_{it} > 0 \\ \infty & if \max\limits_t d_{it} = 0 \end{cases}$$

Additionally, let $\hat{G}^0\left(\underline{d}_i - \mathbf{X_{it}}\beta, \theta_e\right)$ denote the probability of this student not borrowing for a particular value of $\underline{d}_i$, where:

$$\hat{G}^0\left(\underline{d}_i - \mathbf{X_{it}}\beta, \theta_e\right) := \begin{cases} G\left(\underline{d}_i - \mathbf{X_{it}}\beta, \theta_e\right) & if\, \underline{d}_i \leq \hat{d}_i \\ 1 & if\, \underline{d}_i > \hat{d}_i \end{cases}$$

Thus, the log likelihood for all students when loan limits are known is:

$$\log L\left(\theta|d_i,\mathbf{X_{it}}\right)=\sum_{i=1}^{N}\log\left(\prod_{0<d_{it}<d_{it}^{max}}g\left(d_{it}-\mathbf{X_{it}}\beta,\theta_e\right)\right)+$$
$$\sum_{i=1}^{N}\log\left[\int_{0}^{\hat{d}_i}\left(\prod_{d_{it}=0}\hat{G}\left(\underline{d}_i-\mathbf{X_{it}}\beta,\theta_e\right)\right)\left(\prod_{d_{it}=d_{it}^{max}}1-G\left(d_{it}^{max}-\mathbf{X_{it}}\beta,\theta_e\right)\right)f\left(\underline{d}_i,\theta_d\right)d\underline{d}_i\right]$$

With unknown loan limits, a student may have $d_{it}^{max}<\underline{d}_i$ and still be observed borrowing the maximum allowable amount. Thus, for the unknown-limits model, if we denote positive-but-unconstrained loan amounts by $\tilde{d}_i^{+}:=\{d_{it}\;s.t.\;d_{it}^{max}>d_{it}>0\}$, then the largest possible value of $\underline{d}_i$ is:

$$\tilde{d}_i:=\begin{cases}\min\limits_{t}\tilde{d}_i^{+} & if\;\tilde{d}_i^{+}\neq\{\emptyset\}\\ \infty & if\;\tilde{d}_i^{+}=\{\emptyset\}\end{cases}$$

The probability of not borrowing is $G\left(\underline{d}_i-\mathbf{X_{it}}\beta,\theta_e\right)$ and the log likelihood for all students is:

$$\log L\left(\theta|d_i,\mathbf{X_{it}}\right)=\sum_{i=1}^{N}\log\left(\prod_{0<d_{it}<d_{it}^{max}}g\left(d_{it}-\mathbf{X_{it}}\beta,\theta_e\right)\right)+$$
$$\sum_{i=1}^{N}\log\left[\int_{0}^{\tilde{d}_i}\left(\prod_{d_{it}=0}\hat{G}\left(\underline{d}_i-\mathbf{X_{it}}\beta,\theta_e\right)\right)\left(\prod_{d_{it}=d_{it}^{max}}1-G\left(\max\left(\underline{d}_i,d_{it}^{max}\right)-\mathbf{X_{it}}\beta,\theta_e\right)\right)f\left(\underline{d}_i,\theta_d\right)d\underline{d}_i\right]$$

We implement the estimation by numerically maximizing the log likelihood. We only include a subset of covariates from our reduced form models in $\mathbf{X_{it}}$ and restrict attention to students whose unmet need is greater than their exogenous loan limit, allowing them to choose subsidized loans in amounts up to and including d_{it}^{max}.[47]

[47] The log likelihood is maximized numerically using the optim command in R. We drop observations with expected family contribution that is unobserved or zero and drop students who first borrow in such periods. We winsorize recentered expected family contribution at the 10th and 90th percentiles to prevent rounding and integration errors that occur at the extremes of the distribution for some trial parameter values. We also over-censor loans from above at $d_{it}^{max}-1500$ to avoid obtaining identification from the region just below d_{it}^{max} from which students may round up, so that $d_{it}\in\left[d_{it}^{max}-1500,d_{it}^{max}\right]$ are replaced with $d_{it}^{max}-1500$. This means that in the known-limits log likelihood function we replace $\left(\prod_{d_{it}=d_{it}^{max}}1-G\left(d_{it}^{max}-\mathbf{X_{it}}\beta,\theta_e\right)\right)$ with $\left(\prod_{d_{it}=d_{it}^{max}-1500}1-G\left(\max\left(d_{it}^{max}-1500,\underline{d}_i\right)-\mathbf{X_{it}}\beta,\theta_e\right)\right)$, and similarly, with unknown loan limits we replace $\max\left(\underline{d}_i,d_{it}^{max}\right)$ with $\max\left(\underline{d}_i,d_{it}^{max}-1500\right)$. To speed the optimization we used a randomly selected sample of 10 percent of students and restricted covariates to include d_{it}^{max}, a quadratic in student expected family contribution for each side of the eligibility threshold, and an indicator for Pell Grant eligibility. In our next draft, we will use the entire sample and include dependency status, age, race (white), female, years since college entry, and initial degree program as covariates.

7.2 Estimation results

Estimates from both models indicate that CUNY students have large thresholds below which they will not borrow (Table 9). The average desired loan amount d^* is estimated to be \$795 in the known-limits model and \$543 in the unknown-limits model. However, few students actually borrow such amounts because the values of borrowing threshold $\underline{d}_i$ are large: 80 to 85 percent of students would not borrow less than \$2625, the smallest exogenous loan limit in the sample. Second-year students face a subsidized limit of \$4500, but between 68 and 76 percent would not even be willing to borrow this amount. We consider the two models as bounds of the true values characterizing the distribution of $\underline{d}$, but if we were to select one as preferred using the Akaike Information Criterion we would select the unknown-limits model, which provides the larger estimates of $\underline{d}_i$.

With the estimated model, we can describe a counterfactual world with no borrowing cost (Table 10). According to the known-limits model, if the borrowing cost was eliminated then the share of students who borrow in any given year would more than quintuple, rising from 11 percent to nearly 53 percent. Because these loans would come from the lower part of the distribution where the fixed cost is most prohibitive, the size of loans conditional on borrowing would fall by 39 percent. The unconditional mean loan, however, would more than triple. Results from the unknown-limits model provide the lower bounds for predicted borrowing in the absence of a fixed cost, but these smaller amounts still indicate a radical change from the empirical moments. We obtain similar estimates for the restricted sample of first-year students near the Pell grant threshold.

Panel A of Figure 9 displays actual, predicted, and counterfactual borrowing rates as a function of EFC. With the fixed cost operative (red diamonds and plus markers), both models match the empirical borrowing rate (blue markers) fairly well at all levels of EFC. In particular, the borrowing rate falls discretely when a student becomes eligible for a Pell grant and continues to decrease as EFC falls and Pell Grant aid rises. Predicted borrowing rates when fixed costs are removed (green triangles and "X" markers) are dramatically higher. While the overall pattern of Pell Grants substituting for loans remains the same, borrowing rates are higher at every value of EFC. The two models together imply that between 80 and 90 percent of barely-ineligible students would incur federal loans if borrowing did not entail a fixed cost. Panel B displays the corresponding results for the amount borrowed. The pattern is quite similar, with predicted values of the models with fixed costs matching the data fairly closely, and much more predicted borrowing with no fixed cost. Among Pell-ineligible students, borrowing would roughly quadruple. [48]

[48] Appendix Figure A.8 shows the strong fit of the model to the distribution of loan amounts and the fact that removing the fixed cost increases the number of small loans. Appendix Figure A.9 shows the estimated distribution of borrowing thresholds.

7.3 Factors contributing to the fixed borrowing cost

Our estimates indicate that fixed costs are large and dramatically alter borrowing behavior. The finding that a majority of CUNY students behave as if facing a fixed cost sufficient to prevent them from borrowing less than several thousand dollars is perhaps surprising but is in line with estimated costs of deviating from defaults in other financial settings. Whether complete elimination of the fixed cost is a realistic counterfactual depends on the nature of the fixed cost, to which we now turn.

Thus far, we have remained agnostic about what factors lead CUNY students to behave as though they face a fixed cost of borrowing. This behavior may be influenced by some combination of psychic costs caused by debt aversion, hassle and administrative costs caused by paperwork and other requirements, or cognitive costs caused by deviating from the default offer (\$0, in the case of CUNY). Under the assumption that CUNY students face similar psychic costs of borrowing as other public school students, we can investigate the importance of debt aversion by examining the impact of Pell Grant aid on borrowing in a nationally representative sample. We use data on public school students from the 2008 National Postsecondary Student Aid Study (NPSAS). As shown in Figure A.10, we find no evidence of a discontinuity or kink in total federal loan aid or the probability of borrowing at the Pell Grant eligibility threshold among first-year NPSAS students. Due to small sample sizes in the NPSAS, we cannot reject the possibility that NPSAS and CUNY students have similar borrowing responses to a marginal increase in Pell Grant aid, although estimated crowd-out in the nationally representative sample is always smaller than estimates using the CUNY sample (available upon request).

If we reweight the NPSAS sample to match the characteristics of CUNY students then the two groups should have similar distributions of desired loans and differ in their observed borrowing due to differences in the fixed cost of borrowing. We use propensity-score reweighting, using a specification that incorporates all observable and predetermined characteristics that are available in both the CUNY and NPSAS data, to determine the role that observable characteristics play in the differences in borrowing between CUNY and other public school students. We estimate a borrowing rate of 32 percent among first-year public school students that resemble CUNY students. To match this borrowing rate with the borrowing rate predicted by the known-limit model, we must increase ξ, the parameter indexing the curvature of the borrowing threshold distribution, from the estimated value of 8.47×10^{-5} to 3.95×10^{-4}. With this recalibration, the share of students with a borrowing threshold greater than the \$2625 loan limit falls from 80 percent to 37 percent, and the share with a borrowing threshold greater than the \$4500 loan limit falls from 68 percent to 18 percent. According to these estimates, the median borrowing threshold among CUNY students is 4.4 times that of the average student in the national sample. Similarly, recalibrating the unknown-limit model to match the national sample involves reducing the shares with thresholds above $2625 and $4500 to 42 and 23 percent, and the CUNY median is 5.4 times the national average. Thus, while students across the country still appear to face some common fixed cost of borrowing, such as a psychic cost, the students of CUNY face costs that are far greater.

Although all CUNY institutions offer a default federal loan package of $0, schools differ in the process through which students can request nonzero loan aid. All CUNY schools require a short supplemental application. However, a subset of schools allow students to submit this application online, while the remainder require students to submit the application in person to their institution's financial aid office. If hassle and time costs are important factors contributing to the fixed borrowing cost we observe, we would expect that crowd-out would be lower among students who could submit an application online. Under the identifying assumption that schools that offer an online loan application do not differ from those that do not in ways that also influence borrowing decisions, we can test for heterogeneity in the impact of Pell Grant aid on borrowing along this dimension. We estimate our main specification, fully interacting an indicator for having an online loan application with Pell Grant aid; results are displayed in Table 11. We find no evidence that the impact of Pell Grant aid on borrowing varies by the availability of an online loan application. Although estimated crowd-out is larger for students who have access to an online application, crowd-out for borrowers and would-be borrowers is similar between these two groups. Since all CUNY schools provide a default loan offer of zero, we cannot investigate the extent to which default offers influence behavior directly. However, given that we find no evidence of heterogeneity by implied time and hassle costs, we conclude that default loan offers have potentially important impacts on students' borrowing and educational investment decisions.

8 Conclusion

In this paper, we take advantage of the nonlinearities in the Pell Grant Program's formula to estimate the impact of need-based grant aid on educational attainment and borrowing. Our main results - that Pell Grant aid reduces borrowing and has no lasting impact on educational outcomes - is consistent with traditional models of educational investment under credit constraints. We observe very few CUNY students exhausting their federal loan eligibility, suggesting most students do not face borrowing constraints.

However, among students who borrow, an additional $1 of Pell Grant aid leads to borrowers reducing loans by more than $1, which is inconsistent with traditional models of credit constraints where the marginal cost of borrowing is continuous in debt. To explain this irregularity, we extend the traditional credit constraints framework to allow for discontinuities in the price of borrowing caused by a fixed cost of borrowing. We estimate that this cost induces a substantial portion of CUNY students to forgo borrowing in a given year.

Our model predicts that grant aid may actually reduce the educational attainment of a subset of these students, offsetting the expected improvements among students constrained by loan limits and perhaps explaining our finding of no aggregate effect of Pell Grant aid on educational effort or attainment.

Our findings are likely relevant for a substantial portion of two-year colleges. Among large community colleges, CUNY's practice of $0 loan offers is not uncommon.[49] We gathered information on loan packaging practices from 75 of the 100 largest community colleges (excluding CUNY schools).[50] Of these schools, 52 percent packaged both subsidized and unsubsidized loans, 8 percent only packaged subsidized loans, and 40 percent were similar to CUNY institutions by not packing loans.[51]

In 2013, outstanding student loan debt exceeded $960 billion (Federal Reserve Bank of New York 2013). The choice of the default loan offered to low income students may have important implications for students' borrowing decisions. While Dunlop (2013) estimates that access to federal loan aid increases educational attainment of low-income community college students, in general there is limited evidence concerning the impact of federal loan aid on student outcomes.[52] Furthermore, while estimated returns to higher education suggest that borrowing to finance college is optimal (Avery and Turner 2012), student loan debt may impose costs that alter students' behavior when they enter the labor force or while students are still making educational investments (e.g., Field 2009;Rothstein and Rouse 2011). Imposing a fixed borrowing cost may enhance welfare if student debt distorts future decisions. We leave welfare analysis and estimation of these interesting parameters to future work.

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[49] To our knowledge, no four-year institutions outside of the CUNY system make $0 loan offers.

[50] Four institutions do not participate in federal student loan programs and we were unable to obtain information on loan packaging practices of the remaining 21 institutions. Data on enrollment and federal student loan program participation was drawn from Cochrane and Szabo-Kubitz (2013) and http://projectonstudentdebt.org/files/pub//CC_participation_status_2010-11.pdf.

[51] Many institutions placed additional requirements on potential borrowers, such as attending loan counseling in person, developing an education plan with a school counselor, and/or obtaining a sufficiently high score on an in-person or online financial literacy assessment.

[52] Avery and Hoxby (2004) provide evidence that high ability students respond similarly to offered loans and offered grants when deciding between colleges.

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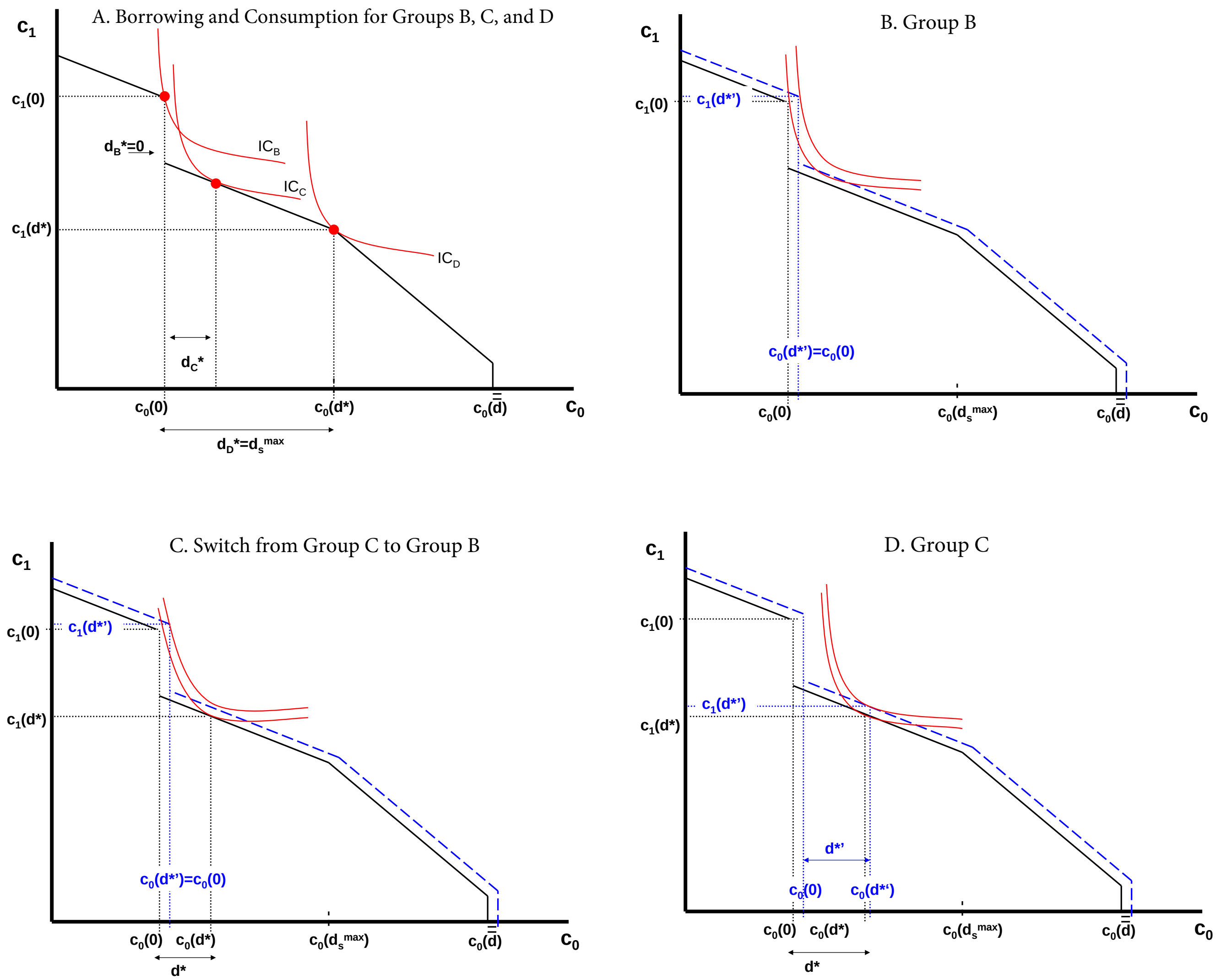
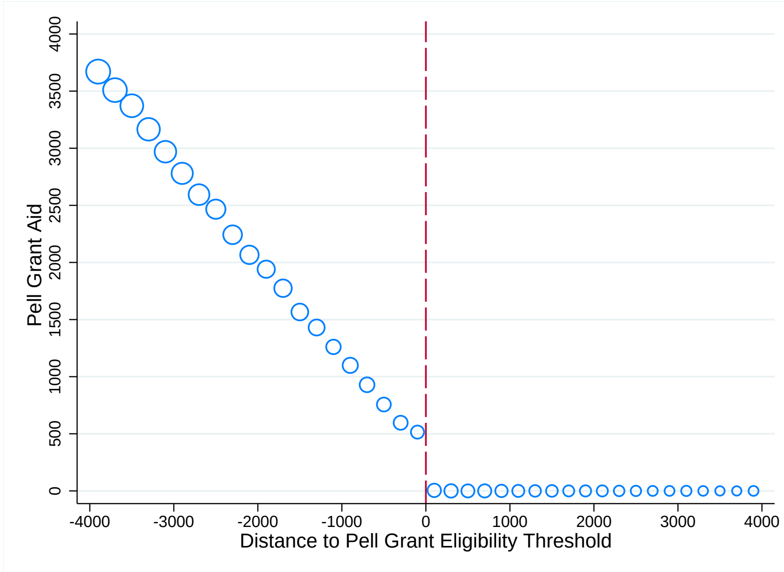
Figures and Tables

Figure 1: The Impact of Pell Grant Aid on Debt by Level of Exogenous Resources



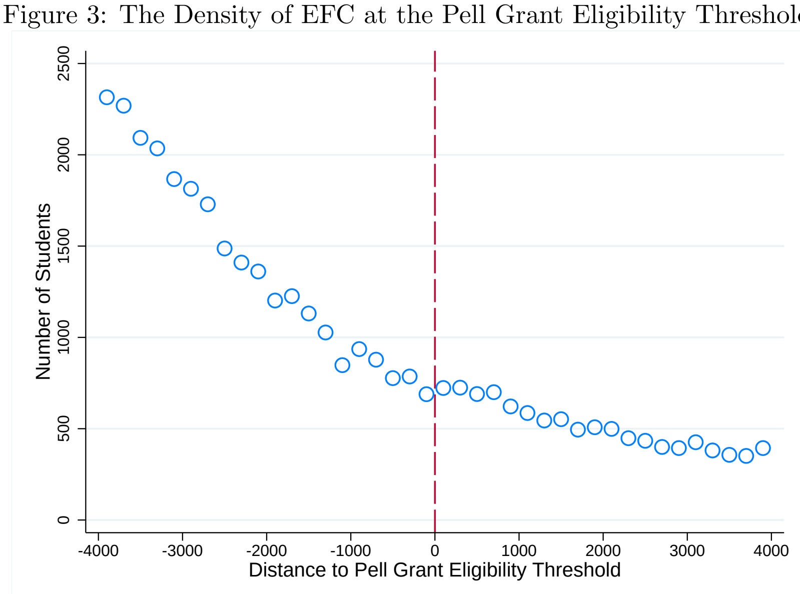
Notes: The black line represents the student's budget constraint in the absence of grant aid (e.g., Panel A), the dashed line represents the student's budget constraint upon the receipt of grant aid, c_0 is consumption in the first period, while c_1 is consumption in the second period. See Section 3 for descriptions of groups. Panel B – $\frac{\partial d}{\partial g} = 0$ and $\frac{\partial s}{\partial g} > 0$. Panel C – $\frac{\triangle d}{\triangle g} < -1$ and $\frac{\triangle s}{\triangle g} < 0$. Panel D – $\frac{\partial d}{\partial g} \in (-1, 0)$ and $\frac{\partial s}{\partial g} = 0$.

Figure 2: The Empirical Distribution of Pell Grant Aid by Distance to Eligibility Threshold



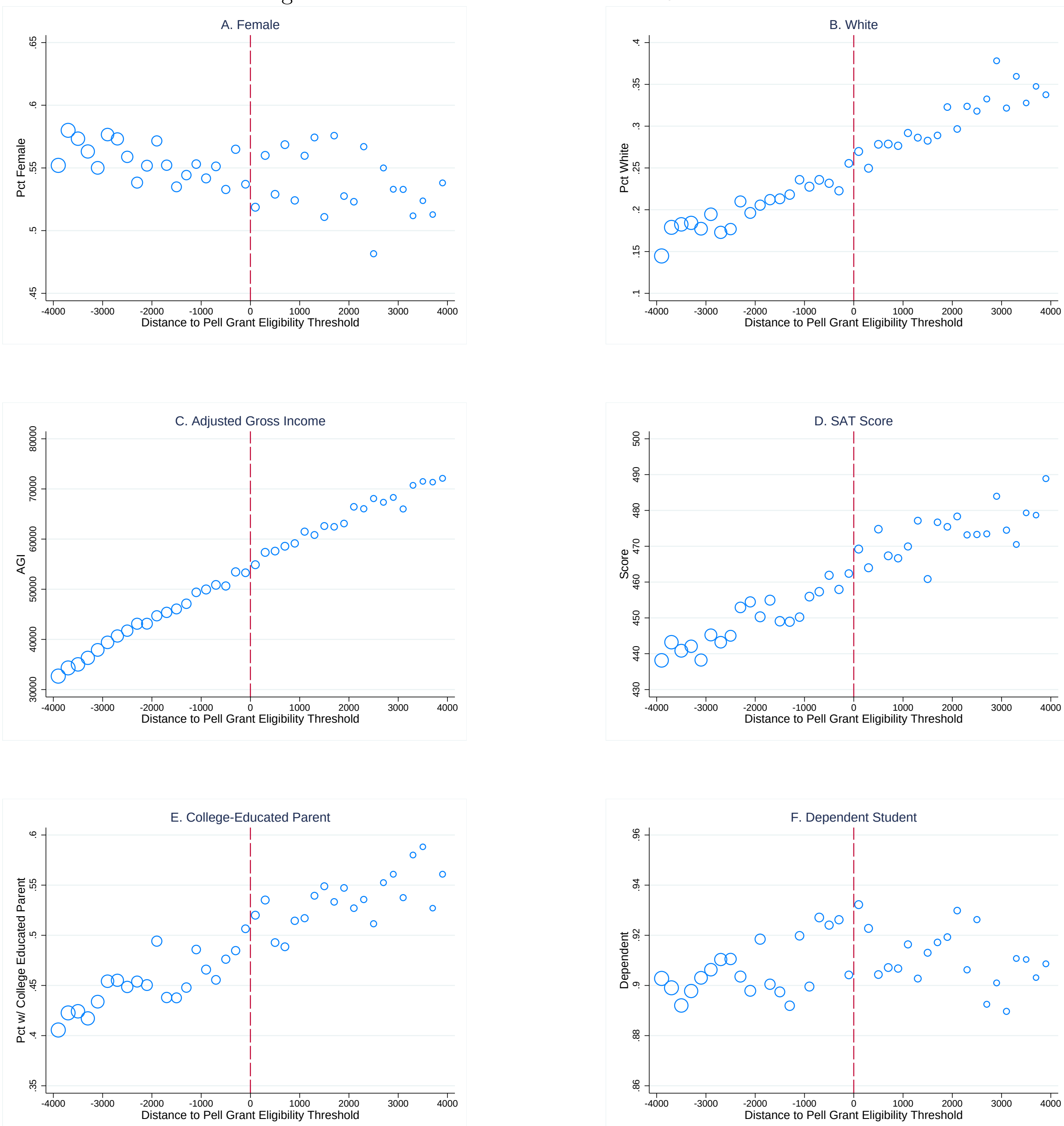
Notes: First-year CUNY undergraduate degree-seeking students; 2007 through 2011 cohorts. $200 EFC bins. Each circle represents the average Pell Grant aid received by students in the bin. Larger circles represent a larger underlying sample size. All dollar amounts adjusted to represent constant 2012$.

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



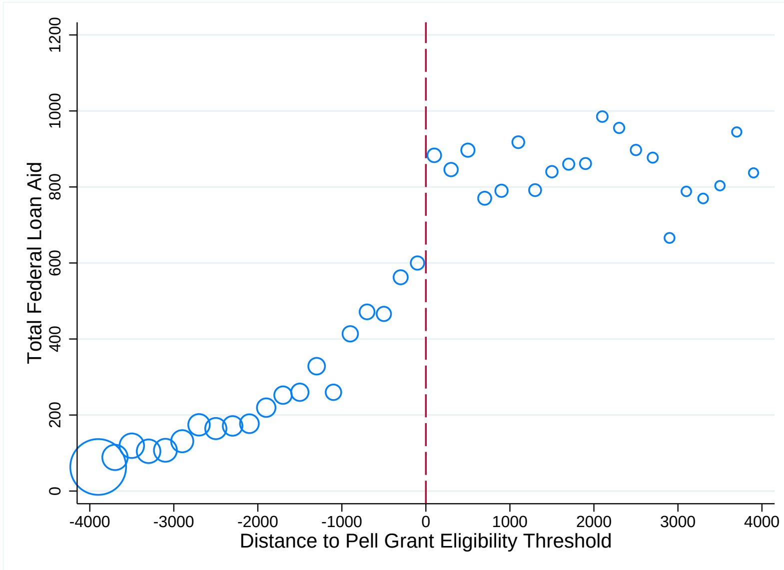
Notes: First-year CUNY undergraduate degree-seeking students; 2007 through 2011 cohorts. $200 EFC bins. Each circle represents the total number of students in the bin. All dollar amounts adjusted to represent constant 2012$. Estimated change in level = -39 (42) and estimated change in slope = -0.45 (0.29) from a regression of the number of students in a given bin on a fifth-order polynomial in $\widetilde{EFC}$ that is allowed to vary on either side of the threshold (degree of polynomial in $\widetilde{EFC}$ chosen to minimize the AIC).

Figure 4: The Distribution of Baseline Characteristics



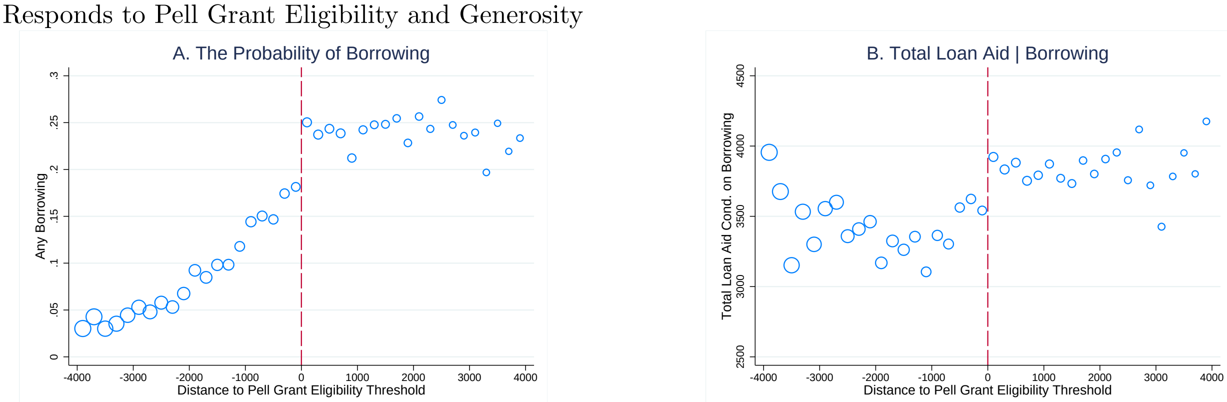
Notes: First-year CUNY undergraduate degree-seeking students; 2007 through 2011 cohorts. $200 EFC bins. Each circle represents the average characteristic of students in the bin. Larger circles represent a larger underlying sample size. All dollar amounts adjusted to represent constant 2012$.

Figure 5: The Reduced Form Impact of Pell Grant Eligibility and Generosity on Total Borrowing



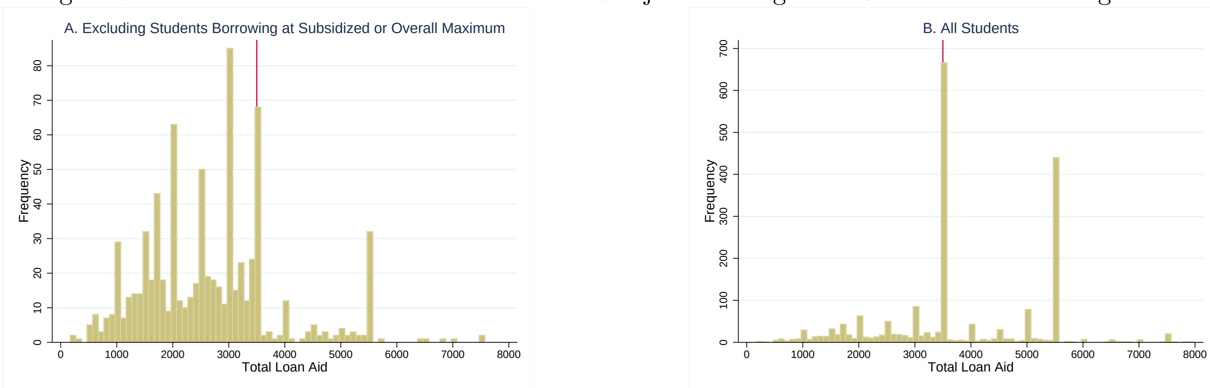
Notes: First-year CUNY undergraduate degree-seeking students; 2007 through 2011 cohorts. \$200 EFC bins. Each circle represents average loan aid (subsidized + unsubsidized Federal Direct Loans) received by students in the bin. Larger circles represent a larger underlying sample size. All dollar amounts adjusted to represent constant 2012\$.

Figure 6: Both the Probability of Borrowing and the Size of Loan Aid Conditional on Any Borrowing Responds to Pell Grant Eligibility and Generosity



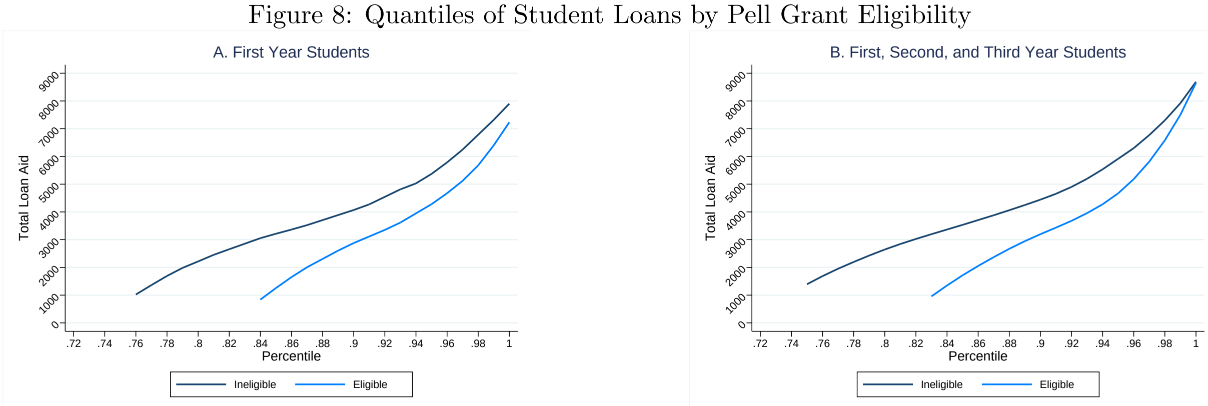
Notes: First-year CUNY undergraduate degree-seeking students; 2007 through 2011 cohorts. \$200 EFC bins. Each circle represents average probability of borrowing (A) or subsidized Federal Direct Loan aid received by borrowers (B) in the bin. Larger circles represent a larger underlying sample size. All dollar amounts adjusted to represent constant 2012\$.

Figure 7: The Distribution of Loans: Borrowers Subject to Exogenous Subsidized Borrowing Limit



Notes: First-year CUNY undergraduate degree-seeking students; 2007 through 2011 cohorts. $100 bins. Dollar amounts in nominal terms.

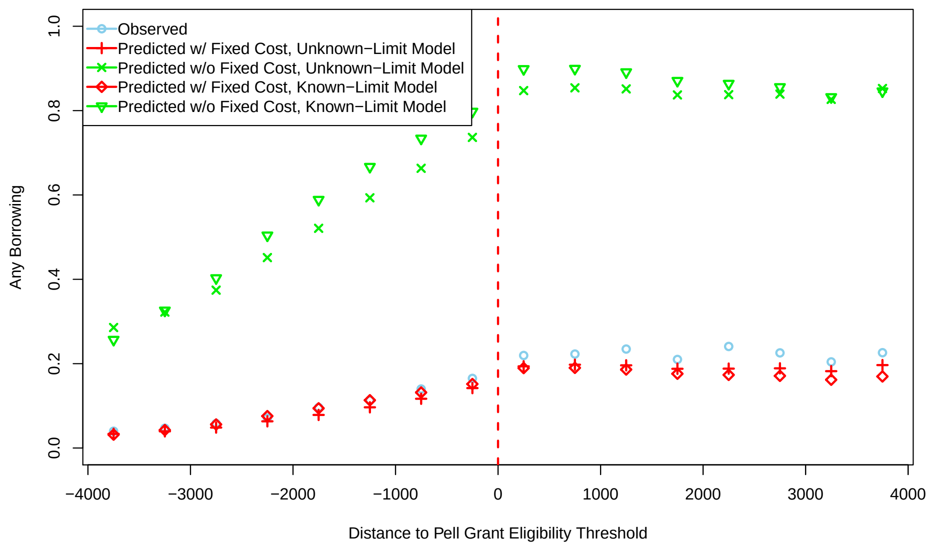
Figure 8: Quantiles of Student Loans by Pell Grant Eligibility



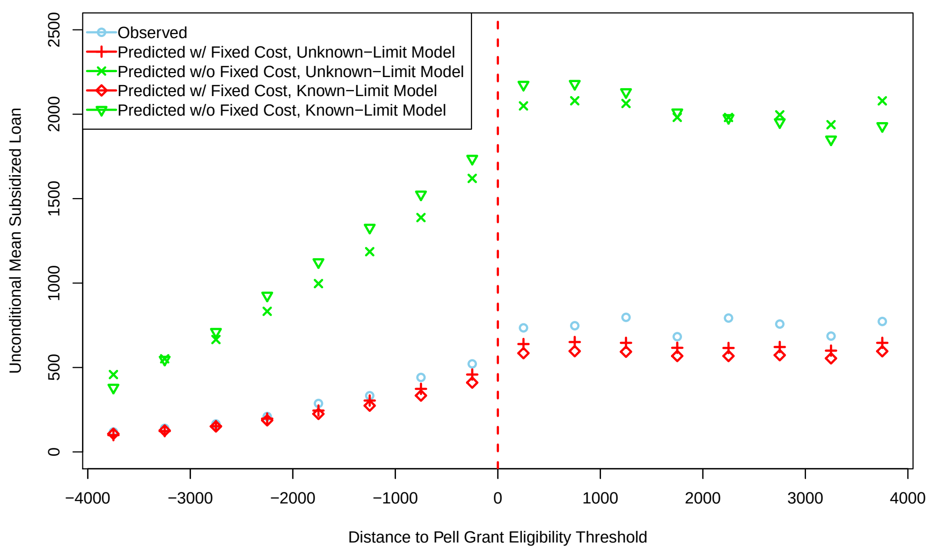
Notes: Panel A: first-year CUNY undergraduate degree seeking students; 2007 through 2011 cohorts. Panel B: first-, second-, and third-year CUNY undergraduate degree-seeking students; 2005 through 2010 cohorts. Students in percentiles that are not listed take on $0 debt. Limited to students with an EFC less than $1000 to the Pell Grant eligibility threshold. All dollar amounts adjusted to represent constant 2012$.

Figure 9: Actual and Counterfactual Borrowing

A. Probability of Borrowing



B. Average Debt



Notes: First-, second-, and third-year CUNY undergraduate degree seeking students; 2007 through 2011 cohorts. \$500 EFC bins. Circles indicate averages (probability of borrowing in Panel A, amount borrowed in Panel B) among students in the bin. Red diamond and plus markers represent predictions from the two maximum likelihood models, one in which students are aware of subsidized loan limits and one in which they do not. Green triangle and X markers are predictions for a counterfactual situation with no fixed cost of borrowing. All dollar amounts adjusted to represent constant 2012\$.

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

	Ineligible	Eligible	Full Sample
Number of Students	10,231	27,869	38,100
A. Cost of Attendance and Financial Aid			
Expected family contribution (EFC)	$6,451	$2,254	$3,381
Total need (= Cost of attendance - EFC)	$6,772	$10,406	$9,430
Total grant aid	$1,012	$4,313	$3,411
Pell Grant aid	$0	$2,394	$1,751
TAP Grant aid	$753	$1,573	$1,352
Percent need met with grants	0.20	0.46	0.39
Any borrowing?	0.24	0.07	0.12
Borrowing at subsidized limit	0.18	0.04	0.08
Subject to endogenous limit	0.34	0.32	0.32
Subsidized borrowing limit	$2,464	$2,556	$2,531
Total loan aid	$923	$244	$427
Share subsidized	0.73	0.80	0.76
B. Student Demographic Characteristics			
Female	0.54	0.56	0.55
Dependent student	0.91	0.90	0.91
Black	0.30	0.34	0.33
Hispanic	0.27	0.33	0.32
White	0.30	0.19	0.22
SAT verbal percentile	0.39	0.32	0.34
SAT math percentile	0.39	0.33	0.34
Foreign-born	0.15	0.19	0.18
Foreign-born parent(s)	0.41	0.47	0.45
Parents' highest education			
Less than high school	0.04	0.06	0.06
High school	0.37	0.40	0.40
College	0.53	0.45	0.47
Parents' resources			
Adjusted gross income	$64,405	$42,522	$48,434
Savings	$6,314	$3,494	$4,252
Student's resources			
Adjusted gross income	$4,422	$3,044	$3,414
Savings	$459	$280	$328
Initial degree program = BA	0.44	0.35	0.37

Notes: First-year CUNY undergraduate degree seeking students; 2007 through 2011 cohorts. COA represents the total cost of attendance, which is equal to tuition and fees, books and supplies, and living expenses. A student's total need is equal to the total cost of attendance minus her EFC. AGI = adjusted gross income. Race and parental education categories may not sum to one due to missing values. Students with EFC greater than $4,000 from Pell Grant eligibility threshold are excluded. All dollar amounts adjusted to represent constant 2012$.

Table 2: Comparing CUNY Students with a Nationally Representative Sample: First-Year, Degree Seeking, Fall 2007 Entering Students who Received Pell Grants

	1. CUNY	2. NPSAS - All Sectors	3. NPSAS - Public Schools
A. Cost of Attendance and Financial Aid			
Expected family contribution (EFC)	$586	$747	$796
Total need (= Cost of Attendance - EFC)	$10,585	$13,067	$9,533
Total grant aid	$5,989	$4,357	$3,932
Pell Grant aid	$3,328	$2,396	$2,390
Percent need met with grants	0.56	0.33	0.41
Any borrowing?	0.04	0.53	0.36
Total loan aid	$108	$2,908	$1,444
Share subsidized	0.88	0.47	0.64
Share private	0	0.25	0.12
B. Student Demographic Characteristics			
Female	0.58	0.65	0.63
Dependent student	0.88	0.47	0.54
Age	19	25	24
Race/ethnicity			
Black	0.29	0.26	0.26
Hispanic	0.39	0.20	0.20
White	0.14	0.45	0.45
SAT verbal percentile	0.22	0.29	0.27
SAT math percentile	0.26	0.25	0.25
Parents' highest education			
Less than high school	0.12	0.19	0.18
High school	0.48	0.32	0.33
College	0.39	0.49	0.49
First generation immigrant	0.26	0.12	0.13
Second generation immigrant	0.27	0.10	0.10
Adjusted gross income	$18,910	$18,804	$19,549
Initial Degree Program = BA	0.35	0.33	0.28

Notes: Column 1: first-year CUNY undergraduate degree seeking Pell Grant recipients. Columns 2: first-year undergraduate degree-seeking Pell Grant recipients from 2008 National Postsecondary Student Aid Study (NPSAS). NPSAS statistics generated using the National Center for Education Statistics Data Analysis System (DAS). Column 2 includes NPSAS students attending schools in all sectors of higher education; column 3 includes NPSAS students attending public institutions. AGI equals parental adjusted gross income for dependent students and student AGI for independent students. COA represents the total cost of attendance, which is equal to tuition and fees, books and supplies, and living expenses. Measures of parental education exclude observations with missing values. Measures of race exclude students with missing race. First generation immigrants are students who were not born in the United States. Second generation immigrants are students who were born in the United States with parents that were foreign-born. Dollar amounts in nominal terms (2008$).

Table 3: The Impact of Pell Grant Eligibility on Pell Grant Aid

	Year 1	Year 2	Year 3
A. OLS Estimates: Impacts on Contemporaneous Pell Grant Aid			
Pell Grant eligible	388.69	370.83	325.37
	(27.60)**	(25.94)**	(31.40)**
× Distance from threshold	-0.761	-0.718	-0.798
	(0.020)**	(0.023)**	(0.033)**
Observations	38,100	27,789	18,955
B. 2SLS Estimates: Impacts on Cumulative Pell Grant Aid			
First year Pell Grant aid	--	1.140	1.189
	--	(0.067)**	(0.128)**
Test coeff = 1: *p* -value	--	0.036	0.140
Mean	$1,750	$3,144	$4,310
Observations	38,100	38,100	32,271

Notes: Panel A: First-, second-, and third-year CUNY undergraduate degree-seeking students; 2005 through 2011 cohorts. Panel B: CUNY undergraduate degree-seeking students; 2007 through 2011 cohorts. Each column within a panel represents a separate regression. Clustered standard errors (institution by year) in parentheses; ** p<0.01, * p<0.05, + p<0.1. All regressions include controls for age, family AGI, and indicators for race (white versus nonwhite), dependency status (dependent versus independent), parents' highest level of education (college, high school, or less than high school), level of attendance (for federal loan eligibility purposes), degree program (AA versus BA), school by year fixed effects, and a quadratic in student expected family contribution ($\widetilde{EFC}_{it} = EFC_{it} - efc_{0t}$, where efc_{0t} is the threshold for Pell Grant eligibility in year t), allowed to vary on either side of the eligibility threshold. Panel B displays 2SLS estimates of the impact of an additional dollar of Pell Grant aid in a student's first year on cumulative Pell Grant aid two and three years after entry; excluded instruments are $\mathbf{1}[\widetilde{EFC}_{it} < 0]$ and $\widetilde{EFC}_{it} \times \mathbf{1}[\widetilde{EFC}_{it} < 0]$. Students with EFC greater than $4,000 from Pell Grant eligibility threshold are excluded. All dollar amounts adjusted to represent constant 2012$.

Table 4: The Impact of Pell Grant Aid on Borrowing

	Year 1	Year 2	Year 3
A. OLS Estimates: Impacts on Contemporaneous Borrowing			
Pell Grant Eligible	-224.45	-220.30	-336.53
	(53.76)**	(66.98)**	(88.70)**
× Distance from Threshold	0.295	0.192	0.535
	(0.075)**	(0.080)*	(0.119)**
Observations	38,100	27,789	18,955
B. 2SLS Estimates: Impacts on Contemporaneous Borrowing			
Pell Grant Aid	-0.428	-0.341	-0.723
	(0.092)**	(0.108)**	(0.139)**
Observations	38,100	27,789	18,955
C. 2SLS Estimates: Impacts on Cumulative Borrowing			
First year Pell Grant Aid	--	-0.592	-0.574
	--	(0.156)**	(0.226)*
Mean	$427	$766	$1,004
Observations	38,100	38,100	32,271
D. Crowd-out | Borrower			
Pell Grant Aid	-1.821	-1.400	-2.430
	(0.281)**	(0.353)**	(0.312)**
H_0: crowd-out > -1, *p* -value	0.002	0.129	<0.001
Observations	38,100	27,789	18,955

Notes: Panels A, B, and D: First-, second-, and third-year CUNY undergraduate degree-seeking students; 2005 through 2011 cohorts. Panel C: CUNY undergraduate degree-seeking students; 2007 through 2011 cohorts. Each column within a panel represents a separate regression. Clustered standard errors (institution by year) in parentheses in Panels A through C; bootstrapped standard errors (clustered at institution by year) in Panel D; ** p<0.01, * p<0.05, + p<0.1. All regressions include controls for age, family AGI, and indicators for race (white versus nonwhite), dependency status (dependent versus independent), parents' highest level of education (college, high school, or less than high school), level of attendance (for federal loan eligibility purposes), degree program (AA versus BA), school by year fixed effects, and a quadratic in student expected family contribution ($\widetilde{EFC}_{it} = EFC_{it} - efc_{0t}$, where efc_{0t} is the threshold for Pell Grant eligibility in year t), allowed to vary on either side of the eligibility threshold. Panel B displays 2SLS estimates of the impact of an additional dollar of Pell Grant aid on contemporaneous borrowing, Panel C displays 2SLS estimates of the impact of an additional dollar of Pell Grant aid in a student's first year on cumulative borrowing two and three years after entry, and Panel D displays 2SLS estimates of the impact of an additional dollar of Pell Grant aid on contemporaneous borrowing scaled by the latent probability of borrowing; excluded instruments are $\mathbf{1}[\widetilde{EFC}_{it} < 0]$ and $\widetilde{EFC}_{it} \times \mathbf{1}[\widetilde{EFC}_{it} < 0]$. F-stat from test of significance of excluded instruments: 656 (Year 1), 491 (Year 2), 313 (Year 3). Students with EFC greater than $4,000 from Pell Grant eligibility threshold are excluded. All dollar amounts adjusted to represent constant 2012$.

Table 5: The Impact of Pell Grant Aid on Borrowing:
Robustness to Varying Bandwidths and Polynomials

Bandwidth:	\$4,000	\$3,000	\$2,000	\$1,000
Polynomial of order:				
One	-0.134	-0.187	-0.320	-0.665
	(0.023)**	(0.037)**	(0.057)**	(0.142)**
	[0.000]	[0.000]	[0.038]	[0.601]
Two	-0.428	-0.557	-0.706	-0.684
	(0.092)**	(0.109)**	(0.169)**	(0.247)**
	[0.116]	[0.867]	[0.875]	[0.779]
Three	-0.599	-0.814	-0.795	-0.771
	(0.148)**	(0.209)**	(0.243)**	(0.327)*
	[0.442]	[0.682]	[0.959]	[0.778]
Four	-0.910	-0.748	-0.773	-1.110
	(0.231)**	(0.254)**	(0.294)**	(0.392)**
	[0.930]	[0.987]	[0.992]	[0.999]
Optimal Order	2	1	1	2
Observations	38,100	25,613	15,645	7,523

Notes: First-year CUNY undergraduate degree-seeking students; 2007 through 2011 cohorts. Each cell represents a separate regression. Standard errors clustered at institution level in parentheses; ** p<0.01, * p<0.05, + p<0.1. All regressions include controls for age, family AGI, and indicators for race (white versus nonwhite), dependency status (dependent versus independent), parents' highest level of education (college, high school, or less than high school), level of attendance (for federal loan eligibility purposes), degree program (AA versus BA), school by year fixed effects, and a polynomial in student expected family contribution ($\widetilde{EFC}_{it} = EFC_{it} - efc_{0t}$, where efc_{0t} is the threshold for Pell Grant eligibility in year t), allowed to vary on either side of the eligibility threshold. Degree of polynomial is indicated in the first column. Optimal order of polynomial chosen using Akaike Information Criterion. Square brackets include p-values from test of joint significance of \$100 EFC bin dummies included as additional regressors. Excluded instruments are $\mathbf{1}[\widetilde{EFC}_{it} < 0]$ and $\widetilde{EFC}_{it} \times \mathbf{1}[\widetilde{EFC}_{it} < 0]$. Students with EFC greater than the indicated distance from Pell Grant eligibility threshold are excluded. All dollar amounts adjusted to represent constant 2012\$.

Table 6: The Impact of Pell Grant Aid on Borrowing:
Other Robustness Tests

	Year 1	Year 2	Year 3
A. Separate RD and RK			
Pell Grant Aid (RD)	-0.577	-0.594	-1.034
	(0.138)**	(0.183)**	(0.298)**
Pell Grant Aid (RK)	-0.387	-0.268	-0.670
	(0.098)**	(0.112)*	(0.150)**
Test of equality (pval)	0.167	0.075	0.244
Observations	38,100	27,789	18,955
B. Accounting for Other Grant Aid			
Pell + Other Grant Aid	-0.410	-0.353	-0.885
	(0.084)**	(0.102)**	(0.202)**
Observations	38,100	27,789	18,953
C. Eliminate Mechanical Effect on Subsidized Loan Eligibility			
Pell Grant Aid	-0.481	-0.373	-0.603
	(0.138)**	(0.171)*	(0.246)*
Observations	24,599	18,071	10,730
D. Excluding covariates			
Pell Grant Aid	-0.415	-0.387	-0.720
	(0.096)**	(0.114)**	(0.149)**
Observations	38,100	27,789	18,955

Notes: First-, second-, and third-year CUNY undergraduate degree-seeking students; 2005 through 2011 cohorts. Panel C sample is limited to Pell Grant eligible students with unmet need greater than the exogenous subsidized borrowing limit and Pell Grant ineligible students with unmet need greater than the sum of the exogenous subsidized borrowing limit and the minimum Pell Grant award. Each column within a represents a separate regression. Clustered standard errors (institution by year) in parentheses; ** p<0.01, * p<0.05, + p<0.1. Panel A through C regressions include controls for age, family AGI, and indicators for race (white versus nonwhite), dependency status (dependent versus independent), parents' highest level of education (college, high school, or less than high school), level of attendance (for federal loan eligibility purposes), degree program (AA versus BA), and school by year fixed effects. All regressions include a quadratic in student expected family contribution ($\widetilde{EFC}_{it} = EFC_{it} - efc_{0t}$, where efc_{0t} is the threshold for Pell Grant eligibility in year t), allowed to vary on either side of the eligibility threshold. Excluded instruments are $\mathbf{1}[\widetilde{EFC}_{it} < 0]$ and $\widetilde{EFC}_{it} \times \mathbf{1}[\widetilde{EFC}_{it} < 0]$ except as indicated in Panel A. Students with EFC greater than $4,000 from Pell Grant eligibility threshold in their first year are excluded. All dollar amounts adjusted to represent constant 2012$.

Table 7: The Impact of Pell Grant Aid on Persistence and Educational Attainment

	Year 1	Year 2	Year 3	Year 3 Cumulative
A. Persistence				
Pell Grant Aid ($1k)	0.012	0.020	0.004	-0.002
	(0.020)	(0.018)	(0.024)	(0.023)
	[-0.03, 0.05]	[-0.02, 0.06]	[-0.04, 0.05]	[-0.05, 0.04]
Mean | Pell Grant ineligible	0.79	0.71	0.7	0.67
Observations	38,100	27,792	18,954	32,271
B. Credits attempted (academic + remedial)				
Pell Grant Aid ($1k)	0.490	0.118	0.797	0.539
	(0.266)+	(0.427)	(0.481)+	(1.190)
	[-0.03, 1.01]	[-0.72, 0.96]	[-0.15, 1.74]	[-1.79, 2.87]
Mean | Pell Grant ineligible	25.5	24.7	24.2	59.8
Observations	38,100	27,792	18,954	32,271
C. Credits earned (academic only)				
Pell Grant Aid ($1k)	0.212	0.594	0.287	0.223
	(0.410)	(0.506)	(0.484)	(1.233)
	[-0.59, 1.02]	[-0.4, 1.59]	[-0.66, 1.24]	[-2.19, 2.64]
Mean | Pell Grant ineligible	17.6	19.6	20	44.7
Observations	38,100	27,792	18,954	32,271
D. Cumulative grade point average				
Pell Grant Aid ($1k)	-0.025	-0.019	0.026	--
	(0.035)	(0.043)	(0.045)	--
	[-0.09, 0.04]	[-0.1, 0.06]	[-0.06, 0.11]	--
Mean | Pell Grant ineligible	2.65	2.71	2.81	--
Observations	34,203	26,083	18,147	--

Notes: First-, second-, and third-year CUNY undergraduate degree-seeking students; 2005 through 2011 cohorts. Each column within a panel represents estimates from a separate regression. Clustered standard errors (institution by year) in parentheses; ** p<0.01, * p<0.05, + p<0.1. Persistence indicates the probability of re-enrolling the following year. All regressions include controls for age, family AGI, and indicators for race (white versus nonwhite), dependency status (dependent versus independent), parents' highest level of education (college, high school, or less than high school), level of attendance (for federal loan eligibility purposes), degree program (AA versus BA), school by year fixed effects, and a quadratic in student expected family contribution ($\widetilde{EFC}_{it} = EFC_{it} - efc_{0t}$, where efc_{0t} is the threshold for Pell Grant eligibility in year t), allowed to vary on either side of the eligibility threshold. Excluded instruments are $\mathbf{1}[\widetilde{EFC}_{it} < 0]$ and $\widetilde{EFC}_{it} \times \mathbf{1}[\widetilde{EFC}_{it} < 0]$. Students with EFC greater than $4,000 from Pell Grant eligibility threshold are excluded. All dollar amounts adjusted to represent constant 2012$.

Table 8: Heterogeneity in the Impact of Pell Grant Aid on Borrowing

	1. Immigrant		2. Dependent Student		3. College Educated Parent		4. BA Degree Program	
	N	Y	N	Y	N	Y	N	Y
A. Dependent Var = Total Loans								
Pell Grant Aid	-0.613	-0.255	-0.424	-0.433	-0.457	-0.458	-0.616	-0.185
	(0.141)**	(0.115)**	(0.436)	(0.087)**	(0.118)**	(0.150)**	(0.125)**	(0.122)
Test of eq: *p*- value	0.053		0.984		0.998		0.013	
Crowd-out | borrower	-2.229	-1.294	-1.606	-1.858	-1.970	-1.877	-2.307	-0.959
	(0.348)**	(0.487)**	(1.531)	(0.253)**	(0.366)**	(0.414)**	(0.324)**	(0.550)+
H_0: crowd-out > -1, *p* -value	<0.001	0.273	0.346	<0.001	0.004	0.017	<0.001	0.470
Test of eq: *p*- value	0.628		0.957		0.962		0.507	
Observations	38,100		38,100		35,011		38,100	
B. Dependent Var = Credits Earned								
Pell Grant Aid ($1k)	0.044	0.442	3.288	-0.018	-0.069	0.720	0.178	0.507
	(0.541)	(0.553)	(1.294)*	(0.431)	(0.717)	(0.540)	(0.562)	(0.523)
Test of eq: *p*- value	0.584		0.018		0.418		0.650	
Observations	38,100		38,100		35,011		38,100	

Notes: First-year CUNY undergraduate degree-seeking students; 2007 through 2011 cohorts. Each column within a panel represents a separate regression; 2SLS estimates of the impact of an additional dollar of Pell Grant aid on contemporaneous borrowing (Panel A) or credits earned during academic year (Panel B). Clustered standard errors (institution by year) in parentheses; ** p<0.01, * p<0.05, + p<0.1. All regressions include controls for age, family AGI, and indicators for race (white versus nonwhite), dependency status (dependent versus independent), parents' highest level of education (college, high school, or less than high school), level of attendance (for federal loan eligibility purposes), degree program (AA versus BA), school by year fixed effects, and a quadratic in student expected family contribution ($\widetilde{EFC}_{it} = EFC_{it} - efc_{0t}$, where efc_{0t} is the threshold for Pell Grant eligibility in year t), allowed to vary on either side of the eligibility threshold. Excluded instruments are $\mathbf{1}[\widetilde{EFC}_{it} < 0]$ and $\widetilde{EFC}_{it} \times \mathbf{1}[\widetilde{EFC}_{it} < 0]$ interacted with an indicator for whether the students attends an institution that requires an in-person loan application. Students with EFC greater than $4,000 from Pell Grant eligibility threshold are excluded. All dollar amounts adjusted to represent constant 2012$.

Table 9: Characterizing the Fixed Cost of Borrowing:
MLE Parameter Estimates

	Known Loan Limits	Unknown Loan Limits
AIC	-2200	-2215
Desired debt d*:		
Mean (at Pell Grant eligiblity threshold)	795	543
	(1)	(1)
Standard deviation	2979	3480
	(135)	(496)
Borrowing thresholds d:		
ξ (parameter of d distribution)	0.00008	0.00006
	(0.000004)	(0.000006)
Share with d > 2625 Loan Limit	0.80	0.85
	(0.01)	(0.02)
Share with d > 3500 Loan Limit	0.74	0.81
	(0.01)	(0.02)
Share with d > 4500 Loan Limit	0.68	0.76
	(0.02)	(0.03)

Notes: First-, second-, and third-year CUNY undergraduate degree-seeking students with non-zero expected family contribution; 2005 through 2011 cohorts. See Section 7 for description of parameters and estimation. Standard errors in parentheses. All dollar amounts adjusted to represent constant 2012$.

Table 10: Observed and Counterfactual Borrowing: Subsidized Loans

	Empirical Moments	Counterfactual: No Fixed Cost of Borrowing			
		Known Loan Limits Model	Percentage Change	Unknown Loan Limits Model	Percentage Change
A. Full Sample					
Share Borrowing	0.109	0.525	382%	0.520	377%
Mean Loan | Borrowing	$3,193	$1,945	-39%	$1,999	-37%
Unconditional Mean Loan	$348	$1,021	193%	$1,039	199%
B. First-year students, EFC within $4000 of Pell Grant eligibility threshold					
Share Borrowing	0.108	0.563	421%	0.531	392%
Mean Loan | Borrowing	$3,087	$1,966	-36%	$1,970	-36%
Unconditional Mean Loan	$333	$1,106	232%	$1,046	214%

Notes: See Figure 9 notes.

Table 11: Heterogeneity in the Impact of Pell Grant Aid on Borrowing by Availability of Online Loan Application

	Online Loan Application	
	N	Y
Pell Grant Aid	-0.417	-0.452
	(0.110)**	(0.166)**
Test of eq: *p*- value	0.859	
Crowd-out | borrower	-1.870	-1.712
	(0.364)**	(0.464)**
Test of eq: *p*- value	0.935	
H_0: crowd-out > -1, *p* -value	0.009	0.063
Observations	38,100	

Notes: First-year CUNY undergraduate degree-seeking students; 2007 through 2011 cohorts. Each column represents a separate regression; 2SLS estimates of the impact of an additional dollar of Pell Grant aid on contemporaneous borrowing. Clustered standard errors (institution by year) in parentheses; ** p<0.01, * p<0.05, + p<0.1. All regressions include controls for age, family AGI, and indicators for race (white versus nonwhite), dependency status (dependent versus independent), parents' highest level of education (college, high school, or less than high school), level of attendance (for federal loan eligibility purposes), degree program (AA versus BA), school by year fixed effects, and a quadratic in student expected family contribution ($\widetilde{EFC}_{it} = EFC_{it} - efc_{0t}$, where efc_{0t} is the threshold for Pell Grant eligibility in year t), allowed to vary on either side of the eligibility threshold. Excluded instruments are $\mathbf{1}[\widetilde{EFC}_{it} < 0]$ and $\widetilde{EFC}_{it} \times \mathbf{1}[\widetilde{EFC}_{it} < 0]$ interacted with an indicator for whether the students attends an institution that requires an in-person loan application. Students with EFC greater than \$4,000 from Pell Grant eligibility threshold are excluded. All dollar amounts adjusted to represent constant 2012\$.

A Additional Figures and Tables

Figure A.1: Sample CUNY Financial Aid Award Letter

7/8/1988

CUNY

The City University of New York - Baruch College

Chris Dempsey, 5555

Costs in the 2013-14 year

Estimated Cost of Attendance		**$X,XXX** / yr
Tuition and fees	$ X,XXX	
Housing and meals	X,XXX	
Books and supplies	X,XXX	
Transportation	X,XXX	
Other education costs	X,XXX	

Grants and scholarships to pay for college

Total Grants and Scholarships (Gift Aid; no repayment needed)		**$X,XXX** / yr
Grants from your school	$ X,XXX	
Federal Pell Grant	X,XXX	
Grants from your state	X,XXX	
Other scholarships you can use	X,XXX	

What will you pay for college

Net Costs **$X,XXX** / yr

(Cost of attendance minus total grants and scholarships)

Options to pay net costs

Work options

Work-Study (Federal, state, or institutional)	$ X,XXX

Loan Options*

Federal Perkins Loans	$ X,XXX
Federal Direct Subsidized Loan	X,XXX
Federal Direct Unsubsidized Loan	X,XXX

*Recommended amounts shown here. You may be eligible for a different amount. Contact your financial aid office.

Other options

Family Contribution **$X,XXX** / yr

(As calculated by the institution using information reported on the FAFSA or to your institution.)

- Payment plan offered by the institution
- Military and/or National Service benefits
- Parent PLUS Loan
- Non-Federal private education loan

Institutional 1st Year Retention Percentage of Full Time Freshman

89.3%

Low Medium High

Degrees Awarded 2011-2012: 2,716

Loan Default Rate

Percentage of borrowers entering repayment and defaulting on their loan

3.2% This Institution

9.8% National

Median Borrowing

Students at Baruch College typically borrow $9,309 in Federal loans for their undergraduate study. The Federal loan payment over 10 years for this amount is approximately $107.13 per month. Your borrowing may be different.

Repaying your loans

To learn about loan repayment choices and work out your Federal Loan monthly payment, go to: http://studentaid.ed.gov/repay-loans/understand/plans

For more information and next steps:

Baruch College
Financial Aid Office

151 E 25th Street, Room 880
New York, NY 10010
Telephone: (646) 312-1360
E-mail: financialaid@baruch.cuny.edu

The above awards are estimated and based upon the data provided on the FAFSA. For federal loan eligibility, consult with the Office of Financial Aid to understand the rights and responsibilities of borrowing. Be sure to respond timely to financial aid requests for missing information. For more details, visit http://www.cuny.edu/admissions/financial-aid.html

Figure A.2: Sample CUNY Loan Application Form

Academic Year: 2013-2014

HUNTER
City University of New York
695 Park Avenue; New York, NY 10065
Office of Financial Aid
Room 241 North
Tele.: 212-772-4820

Summer 2013
Fall 2013
Spring 2014

WILLIAM D. FORD FEDERAL DIRECT STAFFORD LOAN APPLICATION

(Please **print clearly** in BLACK or BLUE ink)
Incomplete applications will not be processed

Student's Information:

Last Name: ______________________ **First Name:** ______________________ **Middle Initial:** ________

SS#: ________/________/________ **Date of Birth:** ________/________/________

Permanent Address: (*P.O. boxes or dorm addresses CANNOT be used as a permanent address)

Street: ______________________ **Apt#:** ________

City, State: ______________________ **Zip Code:** ________

Mailing Address, if different from permanent address:

Street: ______________________ **Apt#:** ________

City, State: ______________________ **Zip Code:** ________

Phone #: (________)________________ **Hunter E-mail Address:** ________________ **@hunter.cuny.edu**

All loans will be disbursed in two (2) equal payments, Fall 2013 and Spring 2014. If the student is eligible for a Summer 2013 loan and he/she indicates that they would like to be considered for a Summer disbursement, the loan will be disbursed in three (3) payments, instead of two.
**One (1) semester loans will only be processed for graduating students.

I am registered for at least 6 credits during the Summer 2013 semester.	☐ Yes ☐ No	** **Undergraduates Only**: I would like this loan for Summer 2013 only, because I am anticipating Financial Aid for Fall 2013 & Spring 2014. ☐ Yes ☐ No
If yes: I would like to be considered for a Summer loan disbursement.	☐ Yes ☐ No	

I am graduating at the end of the following semester: ☐ Summer 2013 ☐ Fall 2013 ☐ Spring 2014

☐ I am not graduating during the 2013 – 2014 academic year

Total loan amount requested for the 2013-2014 academic year: $ ________ .00

You must round the amount to the nearest whole dollar.

Undergraduates:
I understand that I will be considered for a SUBSIDIZED loan first. ☒ Yes
If I am not eligible for a subsidized loan, I authorize the Office of Financial Aid to process an UNSUBSIDIZED loan. ☐ Yes ☐ No

Graduates:
I understand that Graduate students are no longer eligible for subsidized loans. I authorize the Office of Financial Aid to process an UNSUBSIDIZED loan. ☐ Yes

** **UNDERGRADUATE STUDENTS: Will you be pursuing your first Bachelor's degree during the 2013-14 academic year?** ☐ Yes ☐ No

Borrower's Certification: My signature below certifies that I am aware I must be making Satisfactory Academic Progress in order to receive the Federal Direct Stafford Loan(s) I am applying for. I must complete and sign a Master Promissory Note, if I am required to do so. I also understand that if I have not completed the required steps listed on theright of this application, my loan *will not* be processed. I understand that it is my responsibility to follow up on the status of my loan application if I do not receive notification. I am also aware that my attendance must be verified by the Office of Financial Aid, before a disbursement is made in accordance with the Financial Aid 'Schedule of Payments'.

Applicant's signature: ______________________ **Date:** ________

OFFICE USE ONLY	
UG	G
	SSW
U F S	

Undergraduate Annual Loan Limits and Rates

Crds Completed	Dependent	Independent
0 – 29.9	$5,500 (Max. Subsidized= $3,500)	$9,500 (Max. Subsidized= $3,500)
30 – 59.9	$6,500 (Max. Subsidized= $4,500)	$10,500 (Max. Subsidized= $4,500)
60+	$7,500 (Max. Subsidized= $5,500)	$12,500 (Max. Subsidized= $5,500)

Subsidized interest rate: 6.8% fixed (disbursed on or after July 1st, 2013 and prior to July 1st, 2014)

Unsubsidized interest rate: 6.8% fixed (disbursed on or after July 1st, 2006)

Graduate Annual Loan Limits and Rates

$20, 500

Unsubsidized interest rate: 6.8% fixed (disbursed on or after July 1st, 2006)

**Effective for loan disbursements beginning on or after July 1st, 2012, graduate and professional students are no longer eligible to receive Direct Subsidized Loans. Direct Subsidized Loans disbursed prior to the 2012-2013 academic year are not affected by this change.

REQUIREMENTS:

The following 4 criteria are REQUIRED in order for the Office of Financial Aid to process your loan within 15 business days. When your application is reviewed and the 4 criteria have not been completed, your application will not be processed. The Office of Financial Aid will NOT return any incomplete applications. Check with the Office of Financial Aid after 15 business days to follow up on your application status.

- ☐ Have a valid 2013-2014 FAFSA Application (www.FAFSA.ED.GOV)
- ☐ Must be a matriculated student, registered for at least 6 credits, within your grade level, per semester during the 2013-2014 academic year
- ☐ Complete an 'Entrance Counseling' quiz** (www.STUDENTLOANS.GOV) * You must attach the confirmation page
- ☐ Complete a Master Promissory Note (MPN) ** (www.STUDENTLOANS.GOV)

**Your loan request will be applied to your CUNYfirst account within 15 business days or less.

LOAN ELIGIBILITY DETERMINATION:

The approved loan amount will be determined by CUNY's Cost of Attendance (COA), minus the Expected Family Contribution (EFC), which is determined by your FAFSA application for 2013-2014. Any financial aid and scholarships you are awarded will be deducted from your COA.

NOTIFICATION:

Once your loan is processed you should receive an award notification, by mail, from CUNY's University Application Processing Center. If there are any discrepancies on your award notification, you must contact the Office of Financial Aid immediately. Once a disbursement has occurred, you will receive a disclosure statement from the loan servicing agency.

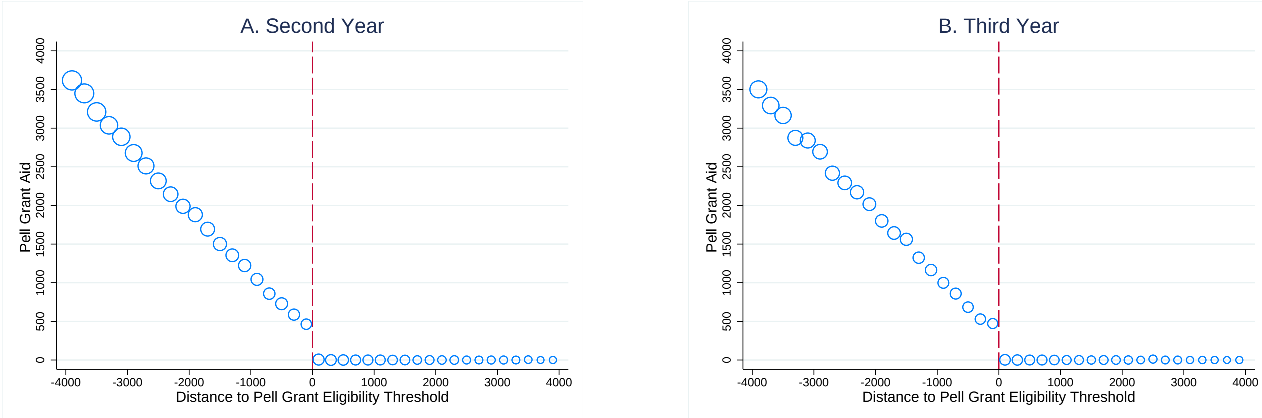
REFUND:

Check Hunter College's 'Schedule of Payments' for loan disbursement dates. Refunds are mailed by check or you can sign up for Direct Deposit, visit www.hunter.cuny.edu/finaid to print the form. **Direct Deposit is strongly encouraged** because you will get your funds on the same day of disbursement. If your check is mailed, you will get it 3 or 5 days later depending on your local post office. If checks are lost via mail it will take about 4 weeks or longer for you to get a replacement check.

** **Note to Transfer Students:** Your 2013-2014 annual loan limit may be affected if you borrowed loans at another institution for Summer 2013 and/or Fall 2013.

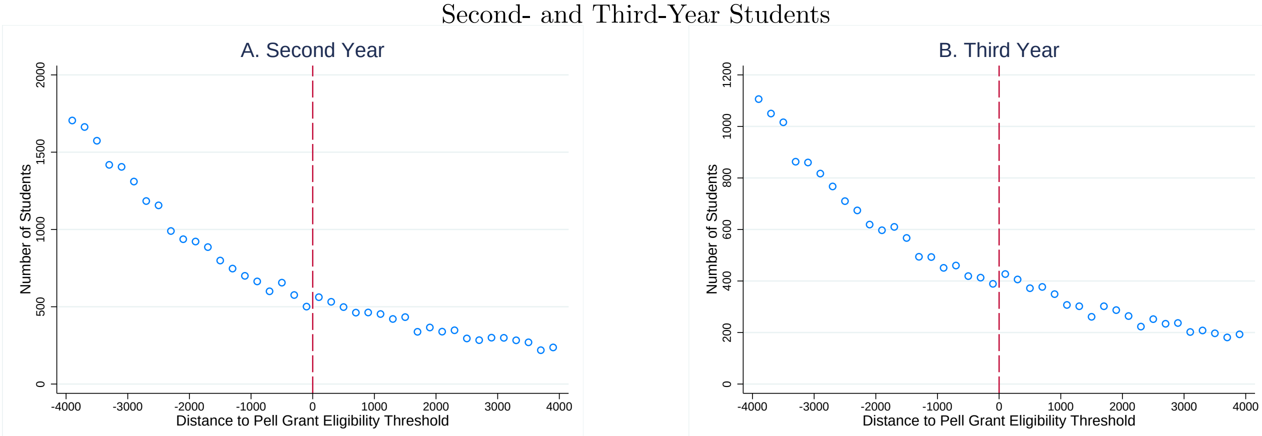
Notes: Available at http://www.hunter.cuny.edu/onestop/finances/financial-aid/.

Figure A.3: The Empirical Distribution of Pell Grant Aid by Distance to Eligibility Threshold: Second and Third Year Students



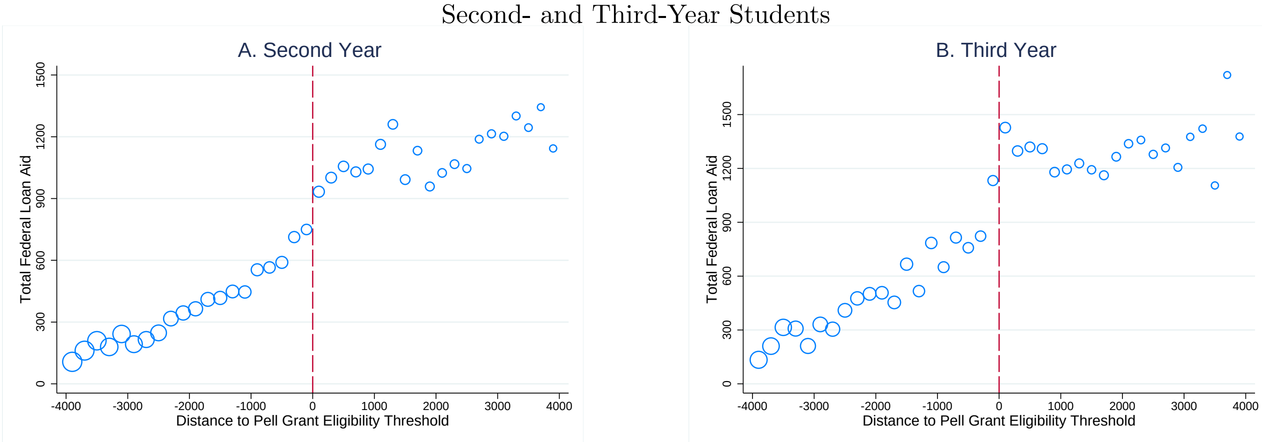
Notes: Second- and third-year CUNY undergraduate degree-seeking students; 2006 through 2009 cohorts. $200 EFC bins. Each circle represents the average Pell Grant aid received by students in the bin. Larger circles represent a larger underlying sample size. All dollar amounts adjusted to represent constant 2012$.

Figure A.4: The Density of EFC at the Pell Grant Eligibility Threshold: Second- and Third-Year Students



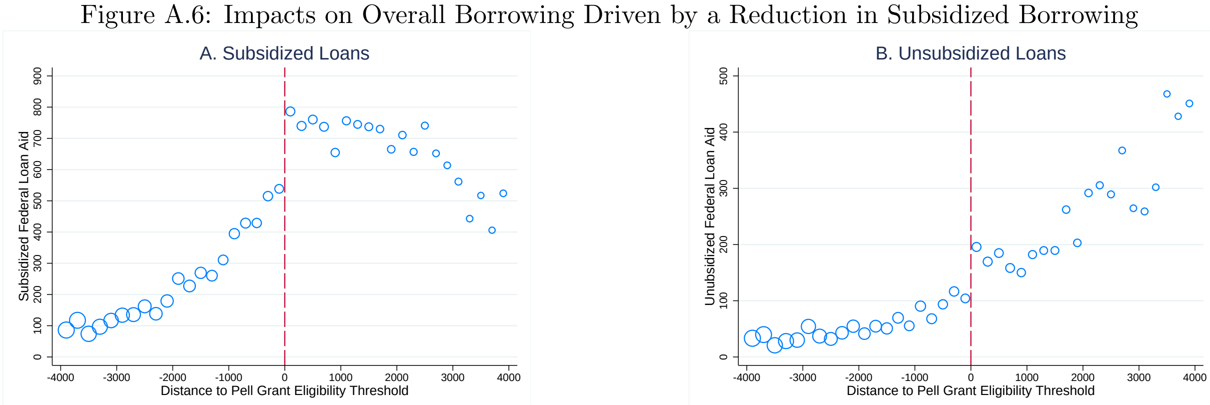
Notes: Second- and third-year CUNY undergraduate degree-seeking students; 2005 through 2011 cohorts. $200 EFC bins. Each circle represents the total number of students in the bin. All dollar amounts adjusted to represent constant 2012$.

Figure A.5: The Reduced Form Impact of Pell Grant Eligibility and Generosity on Total Borrowing: Second- and Third-Year Students



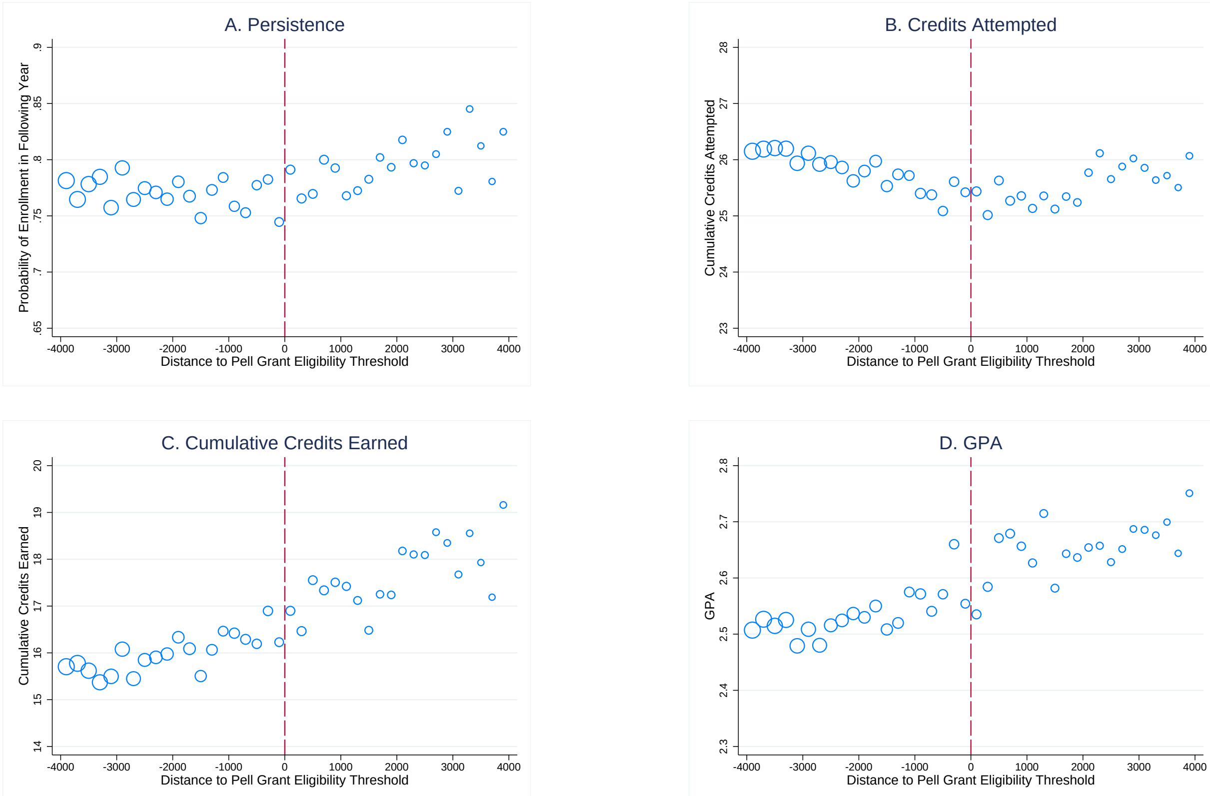
Notes: Second- and third-year CUNY undergraduate degree-seeking students; 2006 through 2009 cohorts. $200 EFC bins. Each circle represents average loan aid (subsidized + unsubsidized Federal Direct Loans) received by students (A) or average probability of borrowing (B) for a given bin. Larger circles represent a larger underlying sample size. All dollar amounts adjusted to represent constant 2012$.

Figure A.6: Impacts on Overall Borrowing Driven by a Reduction in Subsidized Borrowing



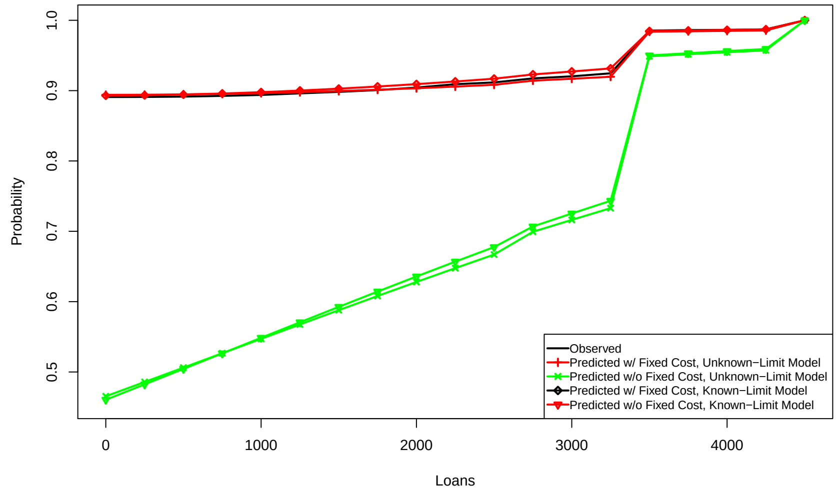
Notes: First-year CUNY undergraduate degree-seeking students; 2008 through 2010 cohorts. $200 EFC bins. Each circle represents average subsidized (A) or unsubsidized (B) Federal Direct Loan aid received by students in the bin. Larger circles represent a larger underlying sample size. All dollar amounts adjusted to represent constant 2012$.

Figure A.7: Reduced Form Impacts of Pell Grant Aid on Educational Outcomes



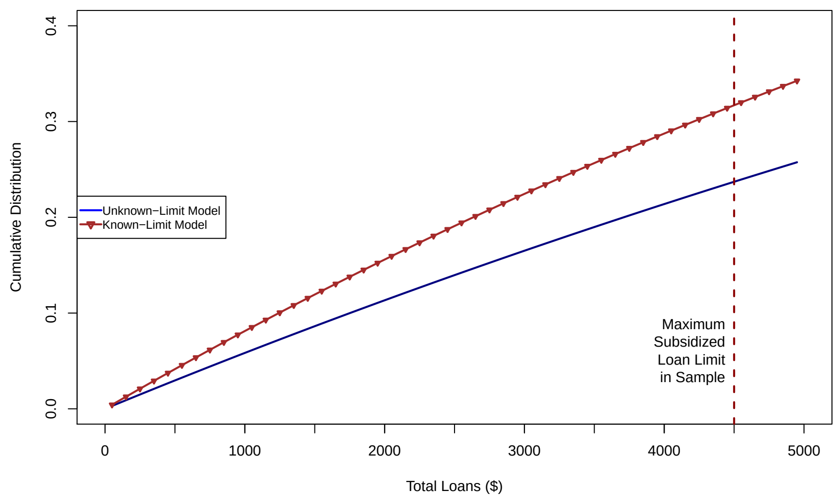
Notes: First-year CUNY undergraduate degree-seeking students; 2008 through 2010 cohorts. $200 EFC bins. Each circle represents the average probability of enrolling in the following year (A), average credits attempted (B), average credits earned (C), and average GPA (D) (all conditional on current enrollment). Larger circles represent a larger underlying sample size.

Figure A.8: Actual and Counterfactual Cumulative Distribution of Loans



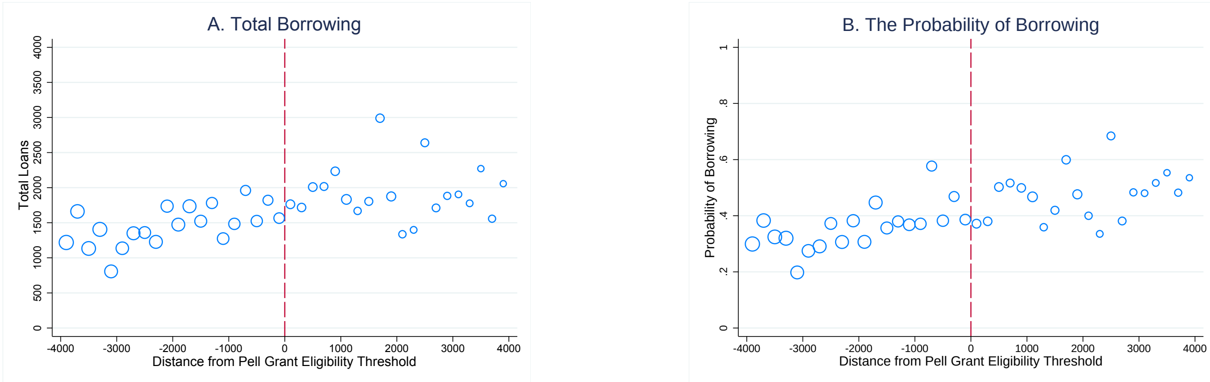
Notes: First-, second-, and third-year CUNY undergraduate degree seeking students; 2007 through 2011 cohorts. $500 EFC bins. Circles indicate share of students with loan debt at or below the indicated level. Red diamond and plus markers represent predictions from the two maximum likelihood models, one in which students are aware of subsidized loan limits and one in which they do not. Green triangle and X markers are predictions for a counterfactual situation with no fixed cost of borrowing. All dollar amounts adjusted to represent constant 2012$.

Figure A.9: Cumulative Distribution of Borrowing Thresholds



Notes: See Section 7 for details.

Figure A.10: Reduced Form Impacts of Pell Grant Aid on Borrowing: NPSAS Sample



Notes: First-year undergraduate degree-seeking students attending public two- and four-year schools in 2008 National Postsecondary Student Aid Studies (NPSAS). $200 EFC bins. Each circle represents the average federal loans (Panel A) or probability of borrowing (Panel B) among students in the bin. All dollar amounts adjusted to represent constant 2012$.

Table A.1: The Relationship between Pell Grant Eligibility and Predetermined Characteristics

	(1) White	(2) Female	(3) Dependent	(4) Age	(5) SAT percentile	(6) AGI	(6) College Ed Parent(s)
A. Year 1							
Pell Grant eligible	-0.007	0.000	0.000	-0.012	-1.304	-1150	-0.024
	(0.014)	(0.018)	(0.010)	(0.112)	(0.689)+	(553)*	(0.017)
× Distance from threshold	-0.00002	-0.00002	0.00001	-0.0001	-0.0001	-1.06	0.000001
	(0.00001)	(0.00002)	(0.00001)	(0.0001)	(0.0008)	(0.78)	(0.00002)
Test of joint sig: *p*- value	0.295	0.789	0.564	0.755	0.170	0.019	0.375
Observations	38,100	38,100	38,100	38,100	24,762	38,100	35,011
B. Year 2							
Pell Grant eligible	0.031	0.006	-0.017	-0.000	-0.495	-2669	-0.027
	(0.018)+	(0.023)	(0.012)	(0.134)	(0.749)	(654)**	(0.019)
× Distance from threshold	-0.00003	0.00003	-0.00001	0.00009	-0.00001	-0.79	-0.00004
	(0.00002)	(0.00002)	(0.00001)	(0.0002)	(0.0008)	(0.86)	(0.00002)
Test of joint sig: *p*- value	0.145	0.362	0.257	0.856	0.795	<0.001	0.088
Observations	27,789	27,789	27,789	27,789	19,651	27,789	25,775
C. Year 3							
Pell Grant eligible	-0.036	-0.004	-0.004	-0.006	-0.430	-2163	-0.009
	(0.019)+	(0.026)	(0.012)	(0.163)	(1.057)	(798)**	(0.023)
× Distance from threshold	-0.00002	-0.000001	0.00003	-0.00016	0.00024	-1.97	-0.00001
	(0.00002)	(0.00003)	(0.00002)+	(0.00020)	(0.00106)	(0.86)*	(0.00003)
Test of joint sig: *p*- value	0.156	0.983	0.241	0.725	0.910	<0.001	0.848
Observations	18,955	18,955	18,955	18,955	11,421	18,955	17,572

Notes: First-, second-, and third-year CUNY undergraduate degree-seeking students; 2005 through 2011 cohorts. Each column within a panel represents a separate regression. Clustered standard errors (institution by year) in parentheses; ** p<0.01, * p<0.05, + p<0.1. All regressions include controls for degree program, school by year fixed effects, and a quadratic in student expected family contribution ($\widetilde{EFC}_{it} = EFC_{it} - efc_{0t}$, where efc_{0t} is the threshold for Pell Grant eligibility in year t), allowed to vary on either side of the eligibility threshold. Students with EFC greater than \$4,000 from Pell Grant eligibility threshold are excluded. All dollar amounts adjusted to represent constant 2012\$.

Table A.2: The Impact of Pell Grant Aid on Subsidized and Unsubsidized Borrowing

	Subsidized Loans			Unsubsidized Loans		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
A. OLS Estimates: Impacts on Loans						
Pell Grant eligible	-164.56	-172.19	-250.09	-59.90	-48.11	-86.44
	(42.03)**	(54.57)**	(72.71)**	(22.96)*	(23.20)*	(34.22)*
× Distance from threshold	0.235	0.172	0.379	0.059	0.020	0.155
	(0.054)**	(0.061)**	(0.088)**	(0.032)+	(0.034)	(0.054)**
Observations	38,100	27,789	18,955	38,100	27,789	18,955
B. 2SLS Estimates: Impacts on Loans						
Pell Grant aid	-0.333	-0.290	-0.518	-0.094	-0.051	-0.205
	(0.066)**	(0.085)**	(0.105)**	(0.041)*	(0.044)	(0.065)**
Observations	38,100	27,789	18,955	38,100	27,789	18,955
C. 2SLS Estimates: Impacts on Cumulative Loans						
First year Pell Grant aid	--	-0.472	-0.402	--	-0.120	-0.173
	--	(0.107)**	(0.149)**	--	(0.072)+	(0.109)
Mean	$325	$546	$707	$102	$220	$297
Observations	38,100	38,100	32,271	38,100	38,100	32,271

Notes: See Table 4 notes.

Table A.3: Contemporaneous Impacts of Pell Grant Aid on Other Sources of Financial Aid

	Year 1	Year 2	Year 3
A. 2SLS Estimates: Impacts on TAP Grant Aid			
Pell Grant Aid	0.051	0.009	0.090
	(0.046)	(0.063)	(0.072)
Observations	38,100	27,789	18,955
B. 2SLS Estimates: Impacts on Other Grant Aid			
Pell Grant Aid	0.084	0.077	-0.123
	(0.034)*	(0.067)	(0.095)
Observations	38,100	27,789	18,955
C. 2SLS Estimates: Impacts on Total Aid			
Pell Grant Aid	0.789	0.732	0.275
	(0.118)**	(0.142)**	(0.211)
Observations	38,100	27,789	18,955

Notes: First-, second-, and third-year CUNY undergraduate degree-seeking students; 2006 through 2010 cohorts. Other grant aid includes grant aid from all sources (excluding TAP and Pell Grant aid). Each column within a panel represents a separate regression. Standard errors clustered at institution level in parentheses; ** p<0.01, * p<0.05, + p<0.1. All regressions include controls for age, family AGI, and indicators for race (white versus nonwhite), dependency status (dependent versus independent), parents' highest level of education (college, high school, or less than high school), level of attendance (for federal loan eligibility purposes), degree program (AA versus BA), school by year fixed effects, and a quadratic in student expected family contribution ($\widetilde{EFC}_{it} = EFC_{it} - efc_{0t}$, where efc_{0t} is the threshold for Pell Grant eligibility in year t), allowed to vary on either side of the eligibility threshold. Excluded instruments are $\mathbf{1}[\widetilde{EFC}_{it} < 0]$ and $\widetilde{EFC}_{it} \times \mathbf{1}[\widetilde{EFC}_{it} < 0]$. Students with EFC greater than $4,000 from Pell Grant eligibility threshold are excluded. All dollar amounts adjusted to represent constant 2012$.

Table A.4: The Impact of Pell Grant Aid on Borrowing: Estimates from Local Linear Regressions

	OLS		2SLS		
	(1) FS	(2) RF	(3) RD	(4) RK	(5) RD/RK
A. Imbens-Kalyanaraman Optimal Bandwidth					
Pell Grant eligible	378.10	-277.63			
	(26.520**	(52.28)**			
× Distance from threshold	-0.798	0.223			
	(0.014)**	(0.047)**			
Pell Grant aid			-0.759	-0.275	-0.321
			(0.142)**	(0.058)**	(0.058)**
Bandwidth	1,639	2,078	2,078	2,078	2,078
Observations	12,519	16,360	16,360	16,360	16,360
B. Fan-Gijbels Rule of Thumb Bandwidth					
Pell Grant eligible	379.20	-253.63			
	(25.52)**	(58.60)**			
× Distance from threshold	-0.767	0.336			
	(0.013)**	(0.091)**			
Pell Grant aid			-0.657	-0.429	-0.492
			(0.149)**	(0.114)**	(0.101)**
Bandwidth	1,774	1,358	1,358	1,358	1,358
Observations	13,726	13,217	13,217	13,217	13,217
C. Ludwig-Miller Cross Validation Bandwidth					
Pell Grant eligible	451.50	-265.10			
	(28.96)**	(53.44)**			
× Distance from threshold	-0.329	0.229			
	(0.122)**	(0.053)**			
Pell Grant aid			-0.720	-0.281	-0.330
			(0.146)**	(0.065)**	(0.065)**
Bandwidth	283	1,942	1,942	1,942	1,942
Observations	2,046	15,150	15,150	15,150	15,150

Notes: First-year CUNY undergraduate degree-seeking students; 2007 through 2011 cohorts. Estimates from local linear regressions of Pell Grant aid and loan aid on Pell Grant eligibility and generosity (OLS estimates) and loan aid on Pell Grant aid (2SLS estimates) using a uniform kernel. Each column within a panel represents a separate regression. Standard errors clustered at institution by year level in parentheses; ** p<0.01, * p<0.05, + p<0.1. See text for description of bandwidth selection procedures.

Table A.5: Heterogeneity in the Impact of Pell Grant Aid on Borrowing by Prior Borrowing

	Prior Borrowing		Prior Borrowing | AA Degree		Prior Borrowing | BA Degree	
	N	Y	N	Y	N	Y
Pell Grant Aid	-0.265	-0.969	-0.321	-0.205	-0.233	-1.305
	(0.066)**	(0.226)**	(0.086)**	(0.382)	(0.086)**	(0.238)**
Test of eq: *p*- value	0.003		0.783		<0.001	
Crowd-out | borrower	-1.992	-1.119	-2.488	-0.245	-1.713	-1.471
	(0.342)**	(0.233)**	(0.449)**	(0.493)	(0.450)**	(0.242)**
Test of eq: *p*- value	0.447		0.278		0.859	
H_0: crowd-out > -1, *p* -value	0.002	0.305	<0.001	0.063	0.113	0.026
Observations	46,744		20,768		25,976	

Notes: First-year CUNY undergraduate degree-seeking students; 2007 through 2011 cohorts. Each column within a panel represents a separate regression. Standard errors clustered at institution by year level in parentheses; ** p<0.01, * p<0.05, + p<0.1. See Table 11 notes for further details

B Proofs

In this appendix we demonstrate that the solution has the form described in Section 3. Proofs of the predictions in Section 3.1 follow directly.

First, the student's problem has between one and two optima. The strict concavity of $u(\cdot)$ and $w(\cdot)$ and convexity of $C(\cdot)$, along with piecewise linearity of the cost of borrowing and the regularity condition $w''(s) \leq -R_m C_t''(s)$, imply that the problem is strictly concave in both d and s where differentiable. The proof is trivial except to note that the regularity condition is sufficient because

$$\frac{\partial^2}{\partial s^2} u(c_1) = \frac{\partial^2}{\partial s^2} u\left(w(s) - R_s d - \kappa_s (R_m - R_s)\left(d - \bar{d} - \xi\left(C_t(s) - g - EFC - \bar{d}\right)\right)\right)$$

$$= \frac{\partial}{\partial s}\left(w'(s) + \kappa_s \xi (R_m - R_s) C_t'(s)\right) u'(c_1)$$

$$= \left(w''(s) + \kappa_s \xi (R_m - R_s) C_t''(s)\right) u'(c_1) + \left(w'(s) + \kappa_s \xi (R_m - R_s) C_t'(s)\right)^2 u''(c_1)$$

and

$$w''(s) \leq -R_m C_t''(s) \Rightarrow w''(s) + \kappa_s \xi (R_m - R_s) C_t''(s) \leq 0 \Rightarrow \frac{\partial^2}{\partial s^2} u(c_1)$$

Therefore, the problem is concave except for the discontinuity at $d = 0$. The domain of s is bounded by assumption, which therefore places bounds on d because consumption cannot be negative. Hence, there is at least one solution. The solution will not include d at the lower bound that makes $c_0 = 0$ because $c_1 > 0 = c_0 \Rightarrow \frac{\partial u(0)}{\partial d} \geq \frac{\partial u(c_1)}{\partial d} \geq \frac{\partial \beta u(c_1)}{\partial d}$, which implies that total utility would be increased by raising d above this level. Similarly, s is bounded from above by non-negativity of c_0 and the fact that d is bounded above by $\bar{\bar{d}}$, and the upper bound for s will not be optimal. Any solution for observed students (for whom the lower bound $s = 0$ is revealed to be suboptimal) satisfies the first order condition with respect to s (1), and either the first order condition with respect to d given by equation (2), $d = 0$, or $d = \bar{\bar{d}}$ (3).

Second, the solution is unique with probability one. Because the entire problem would be concave if not for the discontinuity, and because the discontinuity reduces utility for values of d greater than zero, any solution with $d < 0$ is unique. It may be, however, that an allocation with $d > 0$ gives the same utility as one with $d = 0$. If two solutions exist for a given level of EFC we denote the positive debt amount chosen in one solution by $\underline{d}$. Because student resources are continuously distributed, $\underline{d}$ is optimal with probability zero.

Third, the solution takes the monotonically ranked form described in Section 3. The empirical size (possibly zero) of each group will depend on the parameter values and the distribution of resources among students. Here we establish the theoretical existence of each group of students and their ranking by resources.

Consider schooling level $\bar{s}$ satisfying the equation $R_s C'(\bar{s}) = w'(\bar{s})$ and $\omega = u^{-1}(R_s \beta u(w(\bar{s}) + \epsilon)) + C(\bar{s}) - EFC - g$ for some $\epsilon > 0$. If debt is zero, this allocation gives $u(c_0) = R_s \beta u(w(\bar{s}) + \epsilon) > R_s \beta u(w(\bar{s})) = u(c_1)$. Raising s would increase total utility, but lowering d by an amount that causes the same reduction in c_0 would cause a greater rise in c_1, implying that a negative value of debt must be optimal.

Since $d^* < 0$, $\kappa_0 = \kappa_s = \lambda = 0$. 1 and 2 hold, and combining them gives $R_s C'(s^*) = w'(s^*)$. $\frac{\partial s^*}{\partial g} = 0$, while differentiation of 2 gives $\frac{\partial d^*}{\partial g} = -\frac{u''(c_0)}{u''(c_0) + R_s^2 \beta u''(c_1)} \in (-1, 0)$. Note that g and ω are interchangeable in the problem, the optimal allocation responds to ω in the same way that it responds to g: Higher values of ω reduce d^* and have no effect on s^*. The conditions hold until ω becomes low enough that $d^* = 0$. We label those with resources high enough to induce negative borrowing (i.e. net saving) Group A.

At $d^* = 0$, $\frac{\partial d^*}{\partial g} = 0$ and of the first-order conditions only 2 holds. We label the mass of students with exactly zero debt as Group B. Differentiation gives

$$\frac{\partial s^*}{\partial g} = -\frac{C'(s^*)\,u''(c_0)}{C''(s^*)\,u'(c_0) - C'(s^*)^2\,u''(c_0) - w''(s^*)\,u'(c_0) - w'(s^*)^2\,u''(c_0)} > 0$$

Denote the optimal schooling choice when $d^* = 0$ as s_0^* (suppressing the arguments of this function to simplify notation). If the fixed cost of borrower is not too large there will be additional groups with positive debt. Students in Group B obtain utility $u(\omega + EFC + g - C(s_0^*)) + \beta u(w(s_0^*))$. Students with positive debt obtain utility $u(\omega + EFC + g - C(s^*) - \gamma) + \beta u\left(w(s) - R_s d - \kappa_s (R_m - R_s)\left(d - \bar{d} - \xi\left(C_t(s^*) - g - EFC - \bar{d}\right)\right)\right)$. The level of debt for which the two utilities are equivalent is $\underline{d}$. If $\underline{d} < \bar{d}$ there will be a Group C for which $d \in \left(\underline{d}, \bar{d}\right)$ and both 1 and 2 hold. As with Group A, $R_s C'(s^*) = w'(s^*)$, $\frac{\partial s^*}{\partial g} = 0$, and $\frac{\partial d^*}{\partial g} = -\frac{u''(c_0)}{u''(c_0) + R_s^2 \beta u''(c_1)} \in (-1, 0)$. The optimal $d*$ is strictly decreasing with ω except in the region for which small positive amounts of debt are dominated by zero debt as a result of the fixed cost of borrowing.

As resources continue to fall, d^* may rise to the level of d_s^{max}. For Group D, $d^* = d_s^{max} = \bar{d} + \xi\left(C_t(s^*) - g - EFC - \bar{d}\right) \Rightarrow \frac{\partial d^*}{\partial g} = \xi\left(C_t'(s^*)\frac{\partial s^*}{\partial g} - 1\right)$, and because 2 holds, $\frac{\partial s^*}{\partial g} > 0$ as was the case for Group B. The conditions and properties of Groups E and F follow those of Groups A and B, respectively.

Derivation of the listed implications follows. Denote ω_X as the highest value of in each Group X and $F(\omega)$ the cumulative distribution function for ω, conditional on g and EFC. The monotonicity of the policy implies that Group F has mass $F(\omega_F)$, Group E has mass $F(\omega_E) - F(\omega_F)$, Group D has mass $F(\omega_D) - F(\omega_E)$, etc. Because the policy function is discontinuous, implications are shown for a discrete change ϵ in the amount of grant aid received.

1. If the fixed cost $\gamma > 0$ then $\underline{d} > 0$ and an increase in grant aid may lead to a greater than \$1 for \$1 reduction in loans for borrowers.

Consider a number $\delta \in (0, \gamma)$ and let $s^*(\gamma - \delta)$ denote optimal schooling when $d^* = \gamma - \delta$. The choice of $d = 0$ and $s = s^*(\gamma - \delta)$ gives strictly greater utility than $d = \gamma - \delta$ and $s = s^*(\gamma - \delta)$. This implies a strictly dominated range of debt values between zero and some $\underline{d} > \gamma > 0$. Now suppose *all* students have $\omega = \omega_C$ and $d = \underline{d}$. An increase in grant aid from g to $g + \delta/2$ induces these students to stop borrowing. Crowd-out is $\frac{\triangle d}{\triangle g} = \frac{\delta}{\delta/2} = 2 > 1$.

2. Grants only increase schooling for students facing some form of borrowing constraint.

This implication follows directly from the schooling policy functions.

3. Grants decrease educational attainment of students whose optimal debt level drops from (weakly) above $\underline{d}$ to a positive amount below $\underline{d}$.

Regardless of the choice of d, the choice of s satisfies 2:

$$C'(s)\,u'(\omega + EFC + g + d - C(s) - \gamma \cdot \kappa_0)$$

$$= \beta \left(w'(s) - \xi \kappa_s (R_m - R_s) C_t'(s)\right) u'\left(w(s) - R_s d - \kappa_s (R_m - R_s)\left(d - \bar{d} - \xi\left(C_t(s) - g - EFC - \bar{d}\right)\right)\right)$$

Label as $\underline{s}$ the value of s that satisfies this equation when $d = \underline{d}$. As shown above, the choice of $d = 0$ dominates $d \in (0, \underline{d})$. An increase in grants that induces switching from $d = \underline{d}$ *to* $d = 0$ decreases the value of the left-hand side of the equation (because of the increase in grants and the fact that $\underline{d} \geq \gamma$) and increases the value of the right-hand side. The necessary adjustment to s is downwards because (assuming $d < d_s^{max}$ to simplify notation):

$$\frac{\partial}{\partial s}\left[C'(s)\,u'(\omega + EFC + g - C(s)) - \beta\left(w'(s)\right) u'(w(s) - R_s d)\right]$$

$$= C''(s)\,u'(c_0) - C'(s)^2 u''(c_0) - \beta w''(s)\,u'(c_1) - \beta w'(s)^2\,u''(c_1)$$

$$> 0$$