PLUS OR MINUS? THE EFFECT OF GRADUATE SCHOOL LOANS ON ACCESS, ATTAINMENT, AND PRICES

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ABSTRACT

In 2006, the federal government effectively uncapped student borrowing for graduate programs with the introduction of the Graduate PLUS loan program. Access to additional federal loans increased graduate students' borrowing and shifted the composition of their loans from private to federal debt. However, the increase in borrowing limits did not improve access to existing programs overall or for underrepresented groups. Nor did access to additional loan aid result in significant increase in constrained students' persistence or degree receipt. We document that among programs in which a larger share of graduate students had exhausted their annual federal loan eligibility before the policy change—and thus were more exposed to the expansion in access to credit—federal borrowing and prices increased.

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1. Introduction

Graduate school is an increasingly common educational choice. The number of adults with an advanced degree more than doubled between 2000 and 2021, and today, over 14 percent of American adults hold a postbaccalaureate degree.[1] Student loans are the predominant form of financial aid available for post-baccalaureate studies, and graduate student debt makes up an increasing share of outstanding student loans, with nearly half of all new federal loans disbursed to graduate students in the 2021-22 academic year (Ma and Pender 2022). Despite the importance of student debt for graduate students and the federal loan portfolio, there is limited causal evidence on whether graduate students are helped or harmed by loans, and the extent to which loan generosity has unintended spillovers on institution behavior.

We fill this gap by studying the 2006 creation of the Graduate PLUS Student Loan Program (hereafter, "Grad PLUS") which effectively eliminated federal loan limits for graduate students making it the largest new federal student aid program in at least two decades.[2] Classic models of human capital investment suggest that increased graduate loan availability could raise credit constrained students' educational investments and subsequent earnings by enabling them afford high-return programs if student debt is underprovided by private markets (Friedman 1955).[3] A sizeable empirical literature provides evidence on the presence and importance of credit constraints at the undergraduate level.[4] However, there is much less evidence on whether binding credit constraints affect the decisions of those on the margin of graduate program attendance and whether the resulting earnings gains are sufficient to service any increases in debt. Additionally, increases in student loan generosity could have consequences for nonborrowers as well if institutions and programs alter prices to "capture" some portion of the additional funds.

In this paper, we provide a comprehensive view of the effects of increases in graduate loan generosity on enrollment, graduation, and program prices. While essentially all graduate students

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[1] See America Counts Staff (2019) and https://www.census.gov/data/tables/2021/demo/educational-attainment/cps-detailed-tables.html.

[2] Grad PLUS allowed graduate students to borrow up to the total cost of attendance, which includes tuition and fees and the estimated cost of books, supplies, and living expenses for a student's graduate program. In the 2003-04 academic year, 37 percent of graduate students with federal loans were borrowing at the existing limit (Woo and Shaw 2015).

[3] Several papers document substantial variation in returns to attending different graduate programs and institutions (e.g., Altonji, Arcidiacono, Maurel 2016; Altonji and Zhong 2021; Altonji, Humphries, Zhong 2022).

[4] See, for example, Keane and Wolpin (2001), Carneiro and Heckman (2002), Cameron and Taber (2004), Stinebrickner and Stinebrickner (2008), Lochner and Monge-Naranjo (2011, 2012), Brown, Scholz, and Seshadri (2012), Bulman et al. (2016), Goodman, Isen, and Yannelis (2018), and Belzil, Maurel, and Sidibe (2021).

gained access to Grad PLUS loans, some students and programs stood to benefit more, namely prospective students seeking to attend more expensive programs, students constrained by pre-Grad PLUS limits, and programs in which many students had exhausted their federal loan eligibility.[5] We take advantage of such variation in exposure to the increase in borrowing limits to estimate causal effects of increased loan access on graduate borrowing, enrollment, degree receipt, and program prices using detailed student-level administrative data covering graduate students enrolled in Texas public and nonprofit higher education institutions.

We find that Grad PLUS increased graduate student debt and shifted a portion of graduate borrowing from private to federal sources. Yet, the increase in loan limits due to Grad PLUS did not increase enrollment in existing graduate programs overall or for underrepresented students who may have fewer alternative sources of financing for graduate education. Similarly, among enrolled students who were constrained by federal borrowing limits, we find little evidence of economically significant increases in persistence or degree receipt when these students gained access to additional federal loans through Grad PLUS. Finally, we find evidence that the creation of Grad PLUS led to significantly higher program prices.

Grad PLUS allowed students to borrow up to the total cost of attendance, which theoretically could facilitate access for students who would have otherwise struggled to finance more expensive programs through savings or private loans. Such constraints may be especially relevant for Black students who – due to historic discrimination in housing and other markets – have access to much lower family wealth, on average, than white students (Derenoncourt et al. 2022).[6] We leverage variation in whether and how much the program increased borrowing limits across different programs and compare the number and demographics of students entering programs with baseline prices exceeding the pre-Grad PLUS federal loan limit to programs in which students would not have experienced an expansion in loan access due to Grad PLUS (i.e., with baseline prices below the limit) before and after the program was created.[7] We find that

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[5] Applicants who have "adverse credit" can be denied a PLUS loan, but more typical measures of ability to repay/credit worthiness are not used, and in the event of a denial, many applicants are able to appeal and ultimately be approved. For example, in the 2011 academic year, less than 1 percent of PLUS loan applicants were ultimately denied (https://www2.ed.gov/policy/highered/reg/hearulemaking/2012/pii2-declinationrates.xls).

[6] More generally, groups that are underrepresented in graduate school may also require a graduate credential to be on equal footing in the labor market. For example, in 2016, Hispanic workers with a graduate degree only earned slightly more than white workers with a bachelor's degree but no graduate education on average ($55,700 versus $50,000, respectively). See https://nces.ed.gov/programs/raceindicators/indicator_RFD.asp.

[7] In practice, our preferred specification also uses variation in the magnitude of the loan limit increase.

students attending programs in which the price exceeded the baseline federal loan limit experienced larger increases in effective loan limits, yet enrollment in such programs did not increase. Estimated effects are small, precise, and statistically insignificant, and we can rule out effects greater than a 1.5 student increase in enrollment (1 percent relative to the average program size) per $1000 increase in loan limits. Nor did the demographics of entering cohorts of students change; our estimates exclude essentially any positive effect on the percentage of entering students who were Black or Hispanic.[8] School-level estimates are similar, suggesting that the creation of new programs after Grad PLUS had no effects on access.

We next examine how increases in loan limits affected outcomes of enrolled students by comparing students who were likely to be affected by the increase in loan availability to those who were unlikely to be affected, before and after Grad PLUS was created. Intuitively, students who borrowed at the statutory federal loan maximum prior to the implementation of the policy should be more likely to take advantage of additional loan availability than those who borrowed less than the statutory limit. Consistent with this, we find that students who were constrained by the pre-Grad PLUS limit increased borrowing by a larger amount than borrowers who were unbound by the limit, and, similar to Bhole (2017), that Grad PLUS led to some substitution away from private loans. However, in contrast to prior research finding positive effects of increases in undergraduate loan limits on human capital accumulation (Black et al. 2020), we find no evidence that Grad PLUS affected constrained graduate students' persistence or degree receipt.[9]

Expanded access to federal loans may also have unintended consequences if institutions and programs alter their prices to "capture" some portion of the additional funds. Previous tests of such behavior—labeled the "Bennett Hypothesis"—has focused on specific student groups, such as veterans (Baird et al 2022) or specific programs, such as undergraduate certificates in for-profit institutions (Cellini and Goldin 2014).[10] Other work has examined student-level price

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[8] Denning and Turner (2023) show that enrollment in and access to graduate programs that tend to lead to high earnings was similarly unaffected.

[9] More generally, research shows that increases in undergraduate loan access improves outcomes for community college students (Dunlop 2013; Wiederspan 2016; Marx and Turner 2019; Barr et al. 2021) and low-income students within four-year institutions (Denning 2019).

[10] An additional set of papers primarily focus on other outcomes, only discussing the effects on price in passing (Cornwell, Mustard, Sridhar 2006), or use a time-series variation in federal aid generosity (Singell and Stone 2007), which may be correlated with macroeconomic conditions and changes in student characteristics.

discrimination (Turner 2017), abstracting from changes in the overall cost of attendance. One exception is Lucca, Nadauld, and Shen (2019), which focuses on expansions in federal aid for undergraduates and documents that among schools in which more undergraduate students had exhausted their federal loan eligibility, higher loan limits led to increases in federal loan aid and tuition.

We use a framework that is similar in spirit to Lucca et al. (2019) but focus on graduate programs, accounting for the wide variation in within-institution graduate program pricing and leveraging detailed administrative data to provide some of the first causal evidence on the effects of federal aid generosity on graduate program prices. Student-level data allows for identification of the programs most likely to be affected by increases in availability of federal loans, namely those in which a larger share of students exhausted their federal loan eligibility in years preceding Grad PLUS. Recent work by Kelchen (2019, 2020) tests for the Bennett Hypothesis in the context of law, business, and medical school programs using the introduction of Grad PLUS using an interrupted time-series design and does not find evidence of a significant break in the growth rate of prices.[11] In contrast, our identification strategy with relies on variation in exposure to higher loan limits, can account for aggregate shocks occurring concurrently with the creation of Grad PLUS.

We find evidence of larger price increases among programs more exposed to Grad PLUS. Specifically, programs with more students constrained by federal loan limits in the years before the creation of Grad PLUS had significantly larger increases in both federal borrowing and prices following the program's creation. Taken together, our estimates suggest that sticker prices went up approximately dollar for dollar with increases in federal loans.

Prior work on the Bennett Hypothesis has not been able to trace out the full effects of the policy, making it difficult to fully understand the welfare consequences of price increases. As an example, Lucca, Nadauld, and Shen (2019) show that an increase in loan limits increased prices but Black et al. (2020) showed that this increase in loan limits also increased graduation and

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[11] The interrupted time-series design cannot account for other time-varying shocks around the creation of Grad PLUS which may have also affected pricing decisions, such as changes in economic conditions during the Great Recession. To address this concern, the author also uses a difference-in-differences design that compares changes in graduate tuition and fees to changes in undergraduate tuition and fees, before and after the creation of Grad PLUS. To identify causal effects, this approach requires the key assumption that trends in undergraduate prices following the creation of Grad PLUS provide a good counterfactual for how graduate prices would have trended in the absence of Grad PLUS. However, undergraduate loan limits increased twice following the creation of Grad PLUS and these increases have been shown to have effects on undergraduate prices (Lucca et al. 2019).

earnings. By considering both the human capital effects and price effects, our paper provides a more complete view of the introduction of a large, publicly funded loan program. Additionally, our setting allows us to test whether the additional revenue from higher prices was invested in students. We use student-level data on other sources of financial aid to test for changes in grant aid and implications for net prices, both overall and for different student groups, to determine whether the additional revenue is reallocated to more disadvantaged students. On average, about one third of the price increase due to Grad PLUS was offset by increases in grant aid, and we estimate that on average, net prices increased by $0.64 per $1 increase in per-student federal borrowing. We find no evidence that the additional grants were directed at Black, Hispanic, or low-socioeconomic status students. The null estimated effects on enrollment and attainment outcomes suggest that the additional revenue from higher prices was not used to expand the size of incoming cohorts of students or to improve the outcomes of enrolled borrowers.

The rest of the paper proceeds as follows: Section 2 discusses the setting and policy environment. We describe our data and empirical methods in Section 3. Sections 4, 5, and 6 discuss our estimates of the effects of Grad PLUS on graduate program access, prices, and graduate student outcomes, respectively, while Section 7 concludes.

2. Setting and policy environment

The main source of federal student aid available to graduate students is student loans. To access federal loans, prospective graduate students must fill out the free application for federal student aid (i.e., FAFSA) which requires detailed information on family structure, income, and assets. These inputs are used to calculate the federal government's measure of need, the expected family contribution (EFC) but unlike the major forms of undergraduate student aid, eligibility for most loans for graduate education do not depend on a student's EFC. Federal loan limits and interest rates are set by statute and, unlike private student loans, are not linked to borrower creditworthiness.[12]

Before the introduction of Grad PLUS, most graduate students could borrow up to $18,500 per year from the federal government through the Stafford Loan Program.[13] Some health

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[12] Bhole (2017) estimates that between 2011 and 2014, 40 to 50 percent of graduate borrowers with private loans likely received a lower interest rate than the prevailing federal rate.

[13] Only $8,500 of this amount could be in the form of subsidized loans. The Budget Control Act of 2011 eliminated subsidized loan eligibility for graduate students after June 30, 2012. Prior to 2007, graduate students faced a lifetime

professional programs had higher limits.[14] Graduate students who faced a cost of attendance that exceeded the Stafford Loan limit needed to make up the difference with private loans, savings, or another source of financing.

The Deficit Reduction Act of 2005 established the Grad PLUS Loan Program, effective July 2006, by allowing graduate students to participate in the Parent Loan for Undergraduate Students (PLUS) Loan Program.[15] Stafford Loan limits also increased by $2,000. The Grad PLUS Program allowed a student to borrow up to the total cost of attendance (COA) less any other grants and federal Stafford loans. A student's COA equals their tuition and fees plus an allowance for estimated living expenses and books and supplies. The allowance for estimated living expenses is almost always set at the institution level and does not vary across students who are not living in housing owned by the institution.[16] However, tuition charges and the estimated cost of books and supplies can vary substantially across graduate programs. As a result, after the creation of Grad PLUS, the only constraint on how much students could borrow from the federal government was determined by institutions' pricing decisions.

3. Data and analysis samples

We use de-identified administrative data from the Texas Education Research Center (ERC). These data come from the Texas Higher Education Coordinating Board (THECB), a state agency that oversees post-secondary education in Texas, and contain individual-level information on enrollment, graduation, and financial aid for all graduate students enrolled in public and nonprofit higher education institutions. We observe the program of study for the vast majority of

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federal borrowing limit of $138,500. Students attending programs with a cost of attendance below the Stafford Loan limit could only borrow up to the cost of attendance.

[14] Medical students (including those studying osteopathic medicine, dentistry, veterinary medicine, and optometry) could borrow an additional $20,000 per academic year while students in public health, health administration, pharmacy, clinical psychology, and chiropractic graduate programs could borrow an additional $12,500 per academic year. Students in these programs faced correspondingly higher lifetime federal borrowing limits as well. See Hegji (2021), Appendix C for additional details.

[15] The PLUS loan program was previously limited to parents of dependent undergraduate students, and we distinguish between this and the program we study by always referring to the Graduate PLUS Loan Program as "Grad PLUS" and the parent program as "Parent PLUS".

[16] Although universities have a good deal of discretion over estimated living expenses (Kelchen, Goldrick-Rab, Hosch 2017), the Federal Student Aid Handbook directs schools to apply cost allowances uniformly across all students within a broad category (e.g., in-state students). A small set of additional costs, such as fees for required professional license or certificate required for students in a given program, can also be included, but must be linked to required expenses directly associated with the program of study. See https://fsapartners.ed.gov/knowledge-center/fsa-handbook/2020-2021/vol3/ch2-cost-attendance-budget for additional details.

graduate students attending public institutions and for a subset of private nonprofit graduate students.[17] We link student records to data from the Texas Workforce Commission containing quarterly earnings records for all workers covered by the Texas Unemployment Insurance (UI) system.[18] Our data starts in the 2000-2001 (hereafter, 2001) academic year, which is the first year in which financial aid information is available.[19]

Nationwide, public and nonprofit institutions produce more than 91 percent of master's degrees and 95 percent of doctoral degrees (de Brey et al. 2022). Thus, the coverage of the ERC data makes it close to ideal for studying how the Grad PLUS program and expanded access to loans affected the decisions of most graduate students and schools.

A. Defining Graduate Programs

Conceptually, a program of study is a series of courses in the same field of study in which students seek the same degree from a given institution (e.g., master's degree in social work at the University of Texas at Austin) and face admissions criteria, tuition, and requirements that are relatively similar within broad categories (e.g., in-state versus out-of-state residency). We are particularly interested in distinguishing between (primarily doctoral) academic degree programs and professional degree programs because of the substantial differences in funding, admissions requirements, and prices.[20] Unfortunately, we do not observe programs of study directly in the data only the credential level (master's degree, professional degree, or doctoral degree) and Classification of Instructional Program (CIP) codes, which we use to identify field of study.[21]

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[17] Appendix B provides additional details on the subset of programs in private nonprofit institutions that are observable prior to degree completion. While some information on for-profit institutions and students is available in THECB data in more recent years, we do not observe graduate student enrollment or outcomes in this sector during the years surrounding the creation of Grad PLUS. Nationally, only 8 percent of graduate students attended for-profit institutions in 2004 (authors' analysis of 2004 National Postsecondary Student Aid Study data, via PowerStats). In Texas, only 2 percent of graduate enrollment was in for-profit institutions in 2004 through 2006 (authors' analysis of IPEDS 12-month enrollment data).

[18] UI records cover employers who pay at least $1500 in gross wages to employees or have at least one employee during twenty different weeks in a calendar year. Students employed by their college or university are not included in these data, but work study funding is observable in the THECB data.

[19] Information on enrollment and attainment within nonprofit institutions is available starting in 2003.

[20] It is common for academic PhD program enrollees to receive tuition waivers and stipends, which is generally very different than the (much more limited) funding available to professional degree-seeking graduate students. For example, in 2004, 33 and 61 percent of graduate students entering an academic PhD program received a tuition waiver and grant, respectively compared to 2 and 7 percent of MBA students (estimates from the 2004 NPSAS via PowerStats, table reference: lezyxo).

[21] We exclude students listed as being in a medical residency as their field of study. Private schools in Texas are required to submit a different information to the Texas Higher Education Coordinating Board, which limits our

For professional degree-seeking students, we define a program as a unique 4-digit CIP code (i.e., field of study) by institution combination. Distinguishing between master's and doctoral degree-seeking students, however, is more challenging due to data limitations, namely that some doctoral degree-seeking students are initially classified as master's degree-seeking if they do not hold a master's degree when they first enroll in the program. We use the percentage of terminal degrees awarded at the master's and doctoral levels within a given 4-digit CIP to distinguish between students in terminal professional master's degree programs and students in academic PhD programs who are initially misclassified. Specifically, if more than 85 percent of degrees within a 4-digit CIP by institution cell are terminal master's degrees, we classify the program as a professional master's degree program. If less than 85 percent of degrees are terminal master's degrees, we classify it as an academic doctoral program. We combine such programs into a single broad category of "academic" programs. We make a few exceptions to this classification scheme: all medical/allied health and education programs are classified as professional degree programs.[22] Additionally, education and engineering programs are defined at the 2-digit CIP code level.[23] Additional details can be found in Online Appendix B and our results are robust to using alternative cut-offs in our classification of academic and professional programs.

B. Analysis Samples

We construct three analysis samples to examine the effects of Grad PLUS on graduate program access, student success, and program prices, respectively. First, to analyze how access to additional loan aid from Grad PLUS affected graduate school enrollment—overall and among specific demographic groups—we construct a program-by-year dataset containing information on the number of entering students, their demographic characteristics, average loan amounts, and baseline (2006) cost of attendance. We focus on a balanced panel of programs that had enrollment in each of the 2004 through 2010 academic years and had at least 20 students per year

nonprofit sample to theology, education, law, and chiropractic programs (identified through tuition codes). See Online Appendix B for additional details.

[22] Medical/allied health programs are those with a 2-digit CIP code of 51, education programs are those with a 2-digit CIP code of 13. This is to match the treatment of these programs in other nationally representative data sets, such as the NPSAS, which classifies health and education programs (including doctoral programs) as being distinct from academic PhD programs.

[23] We defined these programs differently because these large fields of study tend to share common resources and require a common set of classes within the broader 2-digit CIP. CIP codes do not have a consistent mapping to programs. For instance, Psychology is identified by a 2-digit CIP code whereas Sociology is a 4-digit CIP code.

who filed a FAFSA, on average, in 2004 through 2006.[24] Because we are especially interested in examining how expanded federal loan limits affected the enrollment of Black and Hispanic students, our main analysis sample also excludes programs in Historically Black Colleges and Universities (HBCUs). We show that our results are robust to relaxing each of these restrictions.

To study how the loan expansion affected the outcomes of enrolled graduate students, we construct a student-level panel data set. We follow Black et al. (2020) and focus on first-time, entering graduate students who borrowed, and, within entry cohorts, we categorize students as "constrained" and "unconstrained" borrowers depending on whether they were more or less likely to gain access to Grad PLUS loans. Constrained borrowers are first-year entrants whose federal Stafford Loans were equal to the annual limit and unconstrained are first-year borrowers with federal Stafford Loans below this amount.[25]

Our final analysis sample is used to test whether expansions in loan access through Grad PLUS led to higher program prices. We construct a second program-by-year level data set but do not limit the underlying sample to first-time students; rather, we include all students enrolled in the program. The key outcome of interest is the price faced by students in a given program. Unfortunately, we do not observe tuition separately from other components of the overall cost of attendance (i.e., estimated cost of books and supplies and living expenses). We calculate the average cost of attendance for each program (as defined in the previous section) among enrolled students who submitted a federal student aid application.

The tuition component of cost of attendance can depend on the number of credits a student attempts, number of semesters enrolled during the academic year, and, for students in public institutions, whether they are classified as in-state or out-of-state. While the average cost of attendance among students in a given program and year likely is correlated highly with the program's tuition, this measure could also reflect differences in enrollment intensity and the extent to which students enroll in the fall, spring, and/or summer semesters across programs.

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[24] This program-level panel begins in 2004 because data for nonprofit institutions is first available in 2003. We want to consider students who are enrolling in their program for the first time and the way we determine this is by checking for enrollment in the year prior, hence the 2004 is the earliest year where we can determine if someone is enrolling in a program for the first time. We restrict our main analysis sample to programs with at least 20 FAFSA filers, on average, in the pre-period because a program's COA – our best measure of price – is only available in our data for students who filed a FAFSA.

[25] We adjust limits to account for part-year enrollment, but our results are robust to using the full-year limit for all students. We also take into account the higher limits for students attending specific health programs (see Hegji 2021).

Thus, we use a second cost of attendance measure – the predicted cost of attendance for a full-time, full-year student.[26]

C. Characteristics of first-time graduate students

Table 1 shows summary statistics for students enrolled in graduate school for the first time in the 2002 through 2006 academic years ("pre-Grad PLUS") and 2007 through 2010 academic years ("post Grad PLUS"). Over this period, most first-time graduate students were women (58 percent) mirroring similar gender ratios at the undergraduate level. Slightly over half of the students entering graduate school were white, 6 percent were Asian or Pacific Islander (API), 10 percent were Black, 16 percent were Hispanic, and 13 percent were international students. On average, new graduate students were approximately 30 years old and 77 percent were in-state students. Outside of a 2-percentage point decrease in the share of entering students who were white, the demographics of new graduate students did not change after the start of Grad PLUS.

Across all entering cohorts, around 70 percent of first-time graduate enrollees completed a degree within 6 years of entry. The 6-year completion rate grew from 67 percent in the pre-Grad PLUS cohorts to 74 percent for later cohorts, mirroring similar increases in undergraduate graduation rates (Denning et al. 2022). The most common broad areas of study are education (21 percent, across all entering cohorts), business (12 percent), health (13 percent), and engineering (6 percent).

On average, 36 percent of new students borrowed in their first year of attending a graduate program and this fraction grew from 32 percent before Grad PLUS to 40 percent after. Around 10 percent of students borrowed at or above the Stafford Loan annual limit before the Grad PLUS program was created, while 16 percent did so in the post-Grad PLUS period. Total (inflation adjusted, unconditional) first-year student loan debt from all sources grew from approximately $5600 for pre-Grad PLUS cohorts to approximately $7500 for later cohorts. Entering graduate students faced an average (inflation-adjusted) cost of attendance of just over $26,000 prior to Grad PLUS and nearly $30,000 in later years.

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[26] To generate a predicted cost of attendance for full-time, full-year (FTFY) graduate students, we regress a student's COA on credits attempted in each semester, semesters of enrolled, and fixed effects for program and academic year. We use these estimates to predict the FTFY cost of attendance for each program.

4. Effects of increased loan limits on graduate program access

To examine the effects of higher federal loan limits on access to graduate education, we leverage variation in program prices before the creation of the Grad PLUS program as a measure of treatment intensity in a dose-response difference-in-differences framework. Prior to Grad PLUS, students could borrow federal loans up to the lesser of their program's cost of attendance and the Stafford Loan limit. Following Grad PLUS, a program's cost of attendance solely determined a student's borrowing limit. Thus, prior to Grad PLUS, in only a subset of programs could prospective students fully finance their attendance with just federal loans, namely, programs that charged prices below the statutory Stafford Loan limit. Abstracting from price increases, Grad PLUS would not have affected federal borrowing limits or access to these programs and thus, they will serve as our control group. Approximately 71 percent of programs had baseline prices below the Stafford Loan limit.

In contrast, prospective students interested in programs that charged prices higher than the Stafford limit would not have been able to fully finance these programs with existing federal loan options before the creation of Grad PLUS. As a result, students lacking access to other sources of financing, such as private student loans or savings, may have found it difficult to enroll in these programs. Grad PLUS increased borrowing limits for students attending such programs by allowing students to cover the difference between the Stafford Loan limit and cost of attendance (net of grants) through Grad PLUS loans. These programs are where we expect the effects of Grad PLUS-driven loan limit expansion to be most pronounced and are our "treated" group.[27] Among programs that would experience borrowing limit expansions based on pre-period prices, the average increase was approximately $6,000 with a standard deviation of $5,152.[28]

Although Grad PLUS increased effective loan limits for students enrolling in treated programs by the amount that the cost of attendance exceeded the Stafford limit, we classify programs based on their baseline (2006) cost to abstract from changes in program prices induced

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[27] To give a specific example, Grad PLUS should have larger effects on access to a program with a $40,000 COA at baseline than a program with a $20,500 COA (the post-Grad PLUS Stafford limit). The composition of students enrolling in programs with COAs below the pre-Grad PLUS limit should not be as affected, as there was no increase in loan limits for students who enrolled in these programs.

[28] Appendix Table A.1 displays characteristics of control (i.e., zero predicted limit increase) and treatment (i.e., greater than zero predicted limit increase) programs before and after the creation of Grad PLUS.

by higher loan limit.[29] We estimate models in which the variable of interest is the distance between the pre-period price and pre-period Stafford loan limit ("projected limit increase"). This "intent-to-treat" approach has the advantage of requiring fewer assumptions, but the disadvantage of not directly relating changes in enrollment to changes in actual loan limits. Instead, given the key identifying assumption that changes in other factors affecting access after the creation of Grad PLUS are uncorrelated with the projected limit increase, this approach will provide estimates of the effect of a \$1,000 increase in *predicted* loan availability.[30]

We also estimate instrumental variables models in which a program's actual loan limit is the endogenous regressor (because it may be affected by program price after 2006) and the excluded instrument is the projected limit increase. Estimates can be interpreted as the effect of a \$1,000 increase in actual loan limits on outcomes. Under the additional assumption that the projected limit increase only affects student enrollment through effects on actual loan limits and student enrollment responses are monotonic, this approach will provide estimates of the average causal response of actual loan limits on graduate program access.

A. Main estimates

We estimate event-study models of the following form:

$$Y_{pc} = \sum_{c \neq 2006} \gamma^c \left(LimInc_p * \mathbf{1}[Cohort = c] \right) + \theta_c + \theta_p + \varepsilon_{pc} \qquad (1)$$

Where Y_{pc} is an outcome (e.g., the number of students or the fraction of students belonging to a given racial/ethnic group) for program p and entry cohort c, $LimInc_p = \max\{(COA_{p,2006} - Limit_p), 0\}$ represents the predicted increase in borrowing limits due to Grad PLUS (in \$1000) for program p, based on the program's baseline (2006) COA and the annual Stafford Loan limit, and θ_c and θ_p are entry cohort and program fixed effects, respectively. When estimating effects on the demographic composition of entering cohorts, we weight program-year observations by average pre-period enrollment. Although this approach uses both the extensive margin of the policy change and a continuous measure of exposure to the policy change as identifying

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[29] We later show that there was an increase in program prices at programs where more students were constrained by pre-Grad PLUS federal loan limits relative to programs where fewer students were constrained. This effect would reinforce our motivation for using pre-Grad PLUS prices to create a measure of the potential increase in limits that is not contaminated by endogenous pricing responses.

[30] Given that we do observe an increase in prices for more affected programs (as discussed in Section 6), this can be interpreted as the effect of the loan limit increase net of the price increase.

variation, we show that our results are robust to discretizing our measure of treatment to weaken the identifying assumptions required for a continuous difference-in-differences design (Callaway, Goodman-Bacon, and Sant'Anna 2021).[31]

Point estimates of γ^c and corresponding 95 percent confidence intervals from equation (1) are displayed in Figure 1. Panel A shows that the predicted federal loan limit increase based on 2006 prices is quite predictive of the actual increase in borrowing limits.[32] Additionally, in programs with higher predicted federal loan limit increases, per-student Grad PLUS borrowing was significantly higher (Panel B).

We find no evidence that the size or composition of programs where Grad PLUS led to larger expansions in federal loan access was changing differentially before the program was created, providing support for the assumption of parallel trends in outcomes in the absence of Grad PLUS. Figure 1 also shows that in the years following Grad PLUS, neither overall enrollment (Panel C) nor the demographics of entering students (Panels D and E) in programs with larger projected loan limit increases changed differentially relative to unaffected programs.

To provide a summary of these effects, we estimate a more parsimonious model that replaces the indicators for specific cohorts in equation (1) with a single indicator for cohorts that entered after the Grad PLUS program was created, $Post_c$:

$$Y_{pc} = \beta\big(LimInc_p * Post_c\big) + \theta_c + \theta_p + \varepsilon_{pc} \qquad (2)$$

Panel A of Table 2 displays estimates of β from equation (2). We again find small and statistically insignificant effects on enrollment in programs where entering students would have experienced a larger increase in effective borrowing limits. Specifically, a \$1,000 increase in the difference between pre-period cost of attendance and the pre-period limit led to an approximately 1 student decrease in the size of entering cohorts. This represents an approximately 1 percent decrease relative to average program enrollment in the pre-period (131 students).

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[31] Specifically, a stronger "parallel trends assumption" is required: that for all doses of treatment (i.e., magnitudes of the difference between baseline COA and the Stafford Loan limit), the average evolution in outcomes in the post-treatment period across all units if they had been assigned that amount of dose is the same as the average evolution in outcomes over time for all units that actually experienced that dose of treatment.

[32] What appears to be a significant pre-period trend in the federal loan limit, dependent variable is adjusted for inflation (2018\$), and as a result, programs with a constant federal limit during this period in nominal terms appear to have a decreasing federal limit in real terms. There is no pre-trend when the dependent variable is the nominal limit.

Columns 2 through 7 of Panel A display estimated effects on the composition of enrolled students, including the percentage of entering students who are Black, Hispanic, Asian and Pacific Islander (API), white. international students, or men. We find small *decreases* in the percent of entering students who were Black and Hispanic and negative insignificant effects on the percent of the entering cohort who was male or an international student.[33] In contrast, we find positive effects, albeit economically small, on the percent of entering students who were white or API. Specifically, a $1000 increase in projected loan limits led to a 0.39 percentage point increase in the percent of entering students who were white and a 0.05 percentage point increase in API students. These results suggest there is very little change in enrollment or class composition as a result of the limit increase.

Panel B displays estimates from IV models in which we instrument for a program's realized limit increase with the projected limit increase. The first stage coefficient is approximately 1.08. IV estimates are quite similar to OLS estimates and quite precise—we can rule out effects larger than a 1.4 student increases in enrollment (1 percent relative to the baseline mean), suggesting that Grad PLUS did not lead to higher enrollment in programs that had larger expansions in federal loan limits. Upper bounds of estimated 95 percent confidence intervals rule out essentially any positive effect of $1000 increase in loan limits on the share of entering students who were Black or Hispanic. Altogether, these estimates suggest that increases in borrowing limits that were caused by Grad PLUS did not expand graduate program access. This is consistent with recent work by Denning and Turner (2023), who show that access to programs that typically lead to high earnings was not affected by expansions in loan limits due to Grad PLUS.

B. Robustness

Our estimates are robust to alternative specifications and sample definitions (Appendix Table A.2). First, to avoid issues with continuous differences in differences designs (Calloway et al. 2022), we use a discrete version of the treatment variable equal to an indicator for having above median pre-period prices (Panel A). Second, we estimate models using an alternative measure of a program's cost of attendance – the average COA from 2004 through 2006 (versus 2006 in our main specification); results are in Panel B. This has the advantage of more data being used to

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[33] Absent program capacity constraints, we would not expect changes in international student enrollment because students in the group are not eligible for federal student loans.

calculate the cost of attendance; however, given trends in tuition, earlier years may be less predictive of future prices than 2006 alone. Third, we use the predicted program price for full-time, full-year students (Panel C). Since we calculate prices using an average of students we observe, the projected limit increase could be biased by differences in students' enrollment intensity if these differences also vary with baseline prices. Predicting the cost of attendance for a full-time, full-year student addresses this concern.

We also estimate models of effects on composition that do not weight observations by baseline program size (Panel D). We expand the years used in estimation to go until 2013 to test for effects on access over a longer time horizon (Panel E). We change the requirement to only have an average of 10 students in the pre-period to see if our restriction to programs with at least 20 entering students in the pre-period influences our results (Panel F). This allows us to use smaller programs but also makes our cost of attendance average more sensitive to outliers. We show our estimates are robust to including HBCU programs in the analysis sample (Panel G). Appendix Table B.2 shows that our estimates are robust to using different thresholds of terminal master's degrees granted to define academic programs. In all cases, our estimates are very similar to those produced by our main specification.

C. New programs and school-level estimates

An additional possibility that our results thus far cannot account for is expansions in access due to the creation of new graduate programs. This is because our identification strategy relies on using pre-Grad PLUS prices to predict loan limit increases, and we do not observe this measure for programs that did not exist prior to Grad PLUS. To explore this possibility, we estimate an institution-level version of equation (2). Because Stafford limits and prices vary within institutions, we calculate the effective limit and projected limit increase for each student who submitted a financial aid application (and thus observe their cost of attendance). We then take the average of these measures across all students in the institution. This approach will capture both changes in enrollment in programs that existed before and after Grad PLUS and increases in enrollment within newly created programs, but at the expense of losing within-institution variation. Appendix Table A.3 contains these estimates, which are quite similar to the program level estimates shown in Table 2.

Our results speak to an often-referenced potential benefit of Grad PLUS—increasing access to programs. We find no such benefit overall. Similarly, we find no effect on the composition of

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entering graduate students, suggesting that binding credit constraints were not the determinative factor for graduate students' ability to enroll in graduate school prior to the advent of Grad PLUS, even among students who are traditionally underrepresented in graduate school. While our main estimates are restricted to programs that existed before the start of Grad PLUS and thus abstract from expansions to access through the creation of *new* programs, to the extent that any new programs would be priced relatively similarly to existing programs, estimates from school-level regressions provide suggestive evidence that this was not the case.

Our finding that Grad PLUS did not increase enrollment or student composition in programs where students would have experienced the largest loan limit increases is also important for our subsequent analyses. If student enrollment had responded to Grad PLUS, the sample of students in graduate school would be endogenously affected by the program's creation, thus complicating analysis using students who enrolled after the policy. However, because we find no evidence that enrollment or observable student characteristics changed, we are able to estimate effects on both students who were enrolled when Grad PLUS was created and those who entered after Grad PLUS led to higher loan limits.

5. Effects on student academic and labor market success

We next focus on estimating the effect of increased liquidity due to Grad PLUS on students' educational attainment and labor market outcomes. Classic models of credit constraints predict that increased access to loans for human capital investment should increase constrained students' borrowing, human capital investment (e.g., graduate school enrollment and completion), and earnings. While we do not see changes in enrollment behavior, it may be that students are able to persist and are more likely to graduate and earn higher earnings with expanded access to credit.[34] We test these predictions in our setting by comparing changes in the outcomes individuals who are likely to be credit constrained to those who are likely unconstrained.

We follow a similar approach to Black et al. (2020) and classify students who borrowed the maximum amount available from Stafford Loans in their first year of the program as "constrained students" and classify those who borrowed less than the maximum amount as unconstrained.[35] We compare the outcomes of constrained and unconstrained students who

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[34] This is what we found among undergraduates in Black et al. (2020) with the expansion of undergraduate student loan limits.

[35] Appendix Table A.4 displays average characteristics of "constrained" and "unconstrained" graduate student borrowers, before and after Grad PLUS was created.

entered in cohorts that were more and less affected by the Grad PLUS increase in borrowing limits and estimate:

$$Y_{ipc} = \beta(Cons_i * Post_c) + \mathbf{X_i}\boldsymbol{\beta_x} + \theta_c + \theta_p + \varepsilon_{ipc} \qquad (3)$$

Where Y_{ipc} is an outcome such as degree completion or annual earnings for student i who belonged to entry cohort c and first enrolled in program p, $Cons_i$ indicates whether a student is classified as constrained (borrowing at Stafford maximum in their first year, accounting for half-year enrollment), and $Post_c$ indicates whether a student belonged to an entry cohort that was potentially affected by Grad PLUS and thus would have gained access to higher federal loan limits due to the establishment of the Grad PLUS program. $\mathbf{X_i}$ is a vector of baseline student characteristics (e.g., age, and indicators for race/ethnicity, gender, college educated parents and enrollment in fall and spring, and main effects for constrained status), θ_c and θ_p are entry cohort and entry program fixed effects, respectively. Standard errors are clustered by entry program.

Under the key identifying assumption that the outcomes of constrained and unconstrained students would have evolved similarly in the absence of loan limit increases due to the establishment of Grad PLUS, estimates of β will represent the causal effect of access to additional federal loans for constrained graduate students. While this assumption is fundamentally untestable, we provide evidence in its support by (1) using event-study models to test for parallel trends in outcomes for cohorts that entered early enough that they would presumably have left graduate school before Grad PLUS existed and (2) testing for differences in baseline demographic characteristics between constrained and unconstrained students for cohorts that were and were not "treated" by the Grad PLUS program.

Following Black et al. (2020), we restrict the sample to enrolled students who borrowed in their first year to enable comparisons between similar students who had demonstrated a need to borrow. We observe first-time graduate students starting with the 2002 entry cohort for public institutions and the 2004 entry cohort for private nonprofit institutions. Focusing on students who made their initial enrollment and borrowing decisions before Grad PLUS loans were available would avoid any possibility of endogenous selection into the sample due to treatment. Given that many graduate programs are two years and our need to condition on first-year borrowing, this restriction would limit us to one year of "post" data for such programs. Given that we find no evidence that programs in which students would have experienced relatively larger increases in

loan limits saw increases in enrollment or changes in student characteristics after Grad PLUS, we also include cohorts of students who entered a graduate program after the implementation of Grad PLUS but before the start of the Great Recession in our analysis sample, and we maintain the assumption that differences in unobservable characteristics of constrained and unconstrained borrowers before and after Grad PLUS are, on average, the same.[36]

A second complication involves identifying *which* entry cohorts were treated by access to higher loan limits. For instance, the 2005 cohort did not gain access to Grad PLUS Loans in their first two years of graduate school, but if they remained enrolled, they would be treated in their third year. Similarly, the 2004 cohort was untreated for its first through third years of graduate school, but students who enrolled for a fourth year would be treated. We test the extent to which earlier entry cohorts gained access to Grad PLUS loans by estimating event study models— similar to equation (3) except $Post_c$ is replaced with a set of entry cohort indicators—in which the dependent variable is cumulative Grad PLUS loans:

$$Y_{ipc} = \sum_{c \neq \underline{c}} \beta^c (Cons_i * \mathbf{1}[Cohort = c]) + \mathbf{X_i}\boldsymbol{\beta_x} + \theta_c + \theta_p + \varepsilon_{ipc} \qquad (4)$$

To determine the last control cohort (which will also serve as the omitted category, $\underline{c}$) we estimate equation (4) and find the last cohort in which constrained students did not see significantly larger increases in Grad PLUS loans compared to unconstrained students, relative to earlier cohorts. Figure 2 displays point estimates and corresponding 95 percent confidence intervals from models in which the 2004 entry cohort serves as the reference group. We estimate effects on cumulative borrowing at entry (dark series with solid markers) and cumulative loans in each of the first through fifth years since entry, where each set of estimates for a given time horizon is delineated by a separate color and symbol. Constrained students in the 2005 through 2008 cohorts saw significant increases in cumulative Grad PLUS loans relative to earlier cohorts. Thus, we classify cohorts that entered before 2005 as untreated and cohorts that entered in 2005 and later as treated.

To verify that the composition of constrained and unconstrained students is not changing between treatment and control cohorts, we first test for differential changes in students' baseline

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[36] We exclude the students who appear to enter graduate school in the first year of available data (2001 for publics and 2003 for nonprofits) to make sure we identify entering students and need at least one year of data to identify if people have enrolled in graduate school previously. Our main analysis sample excludes cohorts who entered after the start of the Great Recession, although our results are robust to including these later entry cohorts.

characteristics, including race, gender, age, parental education, Texas residency, and EFC. To avoid over-rejecting the null due to multiple hypothesis testing, we also create an index of baseline characteristics equal to the probability of receiving a graduate degree within 10 years of entry as a function of these characteristics. Estimates from these placebo analyses can be found in Appendix Table A.5. We find small, statistically insignificant differences in all baseline characteristics except for EFC, which is negative. Reassuringly, we find no evidence of significant changes in the predicted graduation rate.

Figure 3 shows that the effects of Grad PLUS access on cumulative borrowing from all sources is smaller than the increase in Grad PLUS loans. To investigate potential explanations, we estimate the more parsimonious equation (3) and separate out total loans into Grad PLUS, total federal loans (PLUS and Stafford), and a combined category of state and private loans; results are shown in Table 3. We find that access to Grad PLUS loans led to significant increases in constrained students' cumulative federal borrowing in treated entry cohorts and significant decreases in cumulative nonfederal loans. Specifically, 6 years after entry, constrained students borrowed an additional $5,772 in Grad PLUS loans (Panel A), while cumulative federal loans increased by $6,159. However, about 40 percent of the increase in federal borrowing was offset by a $2,578 reduction in state and private loans. Taken together, constrained students who gained access to Grad PLUS experienced significant increases in cumulative total student loans by approximately $3,596.

Thus, Grad PLUS appears to have increased total borrowing while also shifting some existing borrowing from private to federal loans, a result consistent prior estimates based on nationally representative credit bureau data (Bhole 2017). Federal loans, including PLUS loans, may offer better terms than private loans, especially for students with low credit scores or those lacking a long credit history. Additionally, federal borrowers generally have access to a wider variety of repayment options compared to what is offered by private lenders.

We next consider effects on educational attainment. We find that constrained students were no more likely to persist after they gained access to additional federal loans in any year after entry (Table 4, Panel A). Estimated effects on cumulative credits attempted, shown in Panel B, are statistically significant (but economically small) in students' second through tenth years after entry. By the end of our 10-year panel, estimates indicate that constrained borrowers attempted approximately 1.6 additional credits when they gained access to Grad PLUS loans, which is a 3

percent increase from the baseline mean. Finally, we find no evidence of significant increases in graduate degree receipt (Panel Table 4, Panel C and Figure 4). Estimates are small and statistically insignificant – the estimated 95 percent confidence interval excludes effects larger than a 2.7-percentage point increase from a baseline mean of 83.7 percentage points. Similarly, we find no evidence of significant effects on specific degrees (Appendix Tables A.6 through A.8) nor on time to degree among graduates (Appendix Table A.9). So, while constrained students borrowed more when they gained access to Grad PLUS loans, the additional debt did not appear to lead to any meaningful increases in their human capital.

Finally, we examine whether access to additional student loans affected constrained students' labor market outcomes. We first estimate effects on the probability of having any earnings during the academic year.[37] As shown in Panel A of Table 5, we find some evidence that constrained students in affected entry cohorts saw small increases in the probability of having any earnings in UI-covered employment in Texas in their second through sixth years after entry. Estimated effects on the probability of having earnings continue to be positive, albeit insignificant, in the seventh through tenth years after entry. These results complicate the interpretation of earnings results and suggest that Grad PLUS may have had differential effects on the probability of working in Texas for constrained versus unconstrained students. Thus, we follow Foote and Stange (2022), and focus on individuals with nonzero earnings to reduce this bias.

Given that we found no effects on human capital accumulation, it is unsurprising that we find little evidence of effects on long-run earnings (Figure 5). Panel B of Table 5 shows that although constrained students who gained access to Grad PLUS loans had significantly higher earnings one year after entry, estimated effects in all subsequent years are insignificant at the five percent level (Panel B). That said, effects on earnings should be interpreted with some caution as by the end of our panel, we only observe 60.5 percent of the sample with any annual UI-covered earnings in Texas and because we see some evidence of differential selection into observing earnings. The national labor force participation rate for individuals with a post-baccalaureate degree is between 70 and 80 percent, suggesting substantial mobility out of the state (even if the rate of out-migration is not correlated with treatment).[38]

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[37] We align quarters with academic years, i.e., for AY 2010, we sum earnings from 2009-Q4 through 2010-Q3.
[38] See, for instance, https://www.bls.gov/spotlight/2017/educational-attainment-of-the-labor-force/home.htm.

6. Effects on program prices

Finally, we turn to examine the effects of the increase in federal loan availability and borrowing on graduate program prices. Universities, recognizing that students have more ability to pay when loan limits are increased, may try to capture some of the additional funding through higher prices. Ideally, to determine the pass-through of federal loan generosity to institutions, we would compare increases in borrowing to increases in prices. However, realized changes in borrowing after Grad PLUS will be a function of the price increase. Thus, we employ an approach in the spirit of Lucca et al. (2019) and estimate reduced form models in which we compare changes in prices for graduate programs that had a high share of students borrowing at the limit before the Grad PLUS program to changes in prices for graduate programs where few students were constrained by the statutory limit in earlier years.[39] The intuition for this strategy is that programs in which more students were constrained by federal loans limits should see the largest increase in borrowing after these constraints are lifted and will have the most scope to raise prices and see increases in tuition revenue.[40]

Our estimating equation is:

$$Y_{pc} = \beta \left(Pct_{p,pre} * Post_c \right) + \theta_c + \theta_p + \varepsilon_{pc} \qquad (5)$$

Where Y_{pc} is a component of program price such as the cost of attendance, average institutional grants, or average tuition waivers. $Pct_{p,pre}$ represents the average percentage of students borrowing at the pre-Grad PLUS federal loan limit in the pre-period (2003 through 2006), and the other variables are defined as in equation (2).[41]

Our main analysis sample includes a balanced panel of programs with enrollment in every year between 2003 to 2010. We limit our main analyses to programs in which the average

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[39] Our methods differ from Lucca et al. (2019) in that we use population data (versus survey data) to measure exposure to loan limit increases at the program (versus institution) level, examine effects on price levels (versus year-to-year price changes), estimate effects on both list and net price, and test for price discrimination.

[40] We only observe a program's cost of attendance (COA), of which tuition is only one component. Our implicit assumption in using COA as a measure of price is that incentives for schools to change the other components of COA were unaffected by changes in loan limits and borrowing because spending on these other components does not go to the school. Specifically, we assume that the living expense allowance in COA is changing similarly for programs that were more and less exposed to Grad PLUS-driven increases and thus is differenced out.

[41] We define the percent constrained by the number of students who are borrowing from the federal government at or above the Stafford maximum accounting for partial year enrollment. However, we show that our results are robust to using a measure that considers both federal and nonfederal borrowing in defining which students are at the limit or not accounting for partial year enrollment.

number of students submitting financial aid information in a given year in the pre-period is at least 20 to avoid relying on variation from small programs, which will be measured with more noise.[42] We weight program observations by the average number of students for whom we observe cost of attendance in the pre-period. Standard errors are clustered at the institution level.

In the average program, 15 percent of first-year borrowers were constrained, but there is substantial variation in this measure of exposure across programs. In programs within the bottom quartile of fraction of students constrained, less than 3 percent of students were constrained, whereas among programs in the top quartile, more than 18 percent of students were constrained, and 10 percent of programs (weighted by enrollment) had more than 60 percent of students constrained at baseline.[43]

A. Main estimates

Figure 6 shows estimates from an event study model in which $Post_c$ in equation (5) is replaced with indicators for event time (i.e., years before/after 2006). In the years preceding Grad PLUS, program prices trended similarly for programs with low and high shares of students who were constrained by federal loan limits, providing support for our identifying assumptions. After Grad PLUS, however, programs with a higher percentage of students who were constrained at baseline show significantly larger increases in average cost of attendance. Estimated effects are of a similar magnitude to the estimated effects on average Grad PLUS loans received by students in a program.[44]

Table 6 presents estimates from equation (5) of effects on average student loans. Programs that were more exposed to Grad PLUS experienced significantly larger increases in average per-student Grad PLUS and Stafford loans than programs with a lower share of constrained students at baseline. A 1 percentage point increase in the share of students who were constrained by loan limits at baseline corresponds to a $79 increase in average annual Grad PLUS borrowing per student. In total, annual federal loan aid per student increased by $54.[45] Some of the increase in

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[42] We later show the results are robust to relaxing these enrollment-based sample restrictions.

[43] Appendix Table A.10 provides average characteristics of programs in the main analysis sample, before and after Grad PLUS.

[44] In theory, average Grad PLUS loans per student should be $0 for all programs in the pre-period. However, the THECB collected PLUS and SLS loans in the same field. This results in a very small number of students having SLS/PLUS loans in the pre period.

[45] This result suggests that average Stafford Loans taken out by students may have decreased after Grad PLUS (although the point estimates not statistically distinguishable from estimated effects on only Grad PLUS loans). Although students are required to exhaust their Stafford Loan eligibility before borrowing through the Grad PLUS

federal borrowing was offset by the significant $33 decrease in average private student loans per student, while state loan aid was unaffected.[46]

Estimated effects on prices are shown in Table 7. Programs with a higher share of constrained students at baseline see significant increases in the average cost of attendance following the creation of Grad PLUS. A percentage point increase in constrained students at baseline corresponds to an approximately $60 increase in average cost of attendance after Grad PLUS. When we examine effects on the predicted cost of attendance for a full-time, full-year student (column 2), we find significant effects that are of a similar magnitude. Taken together with the results in Table 6, these estimates suggest that prices increased by $0.75 per $1 increase in average per-student Grad PLUS loans and more than dollar for dollar with increases in total federal student loans.

Although Grad PLUS led to relatively larger increases in prices for programs in which students experienced the largest scope for borrowing increases, average grant aid received by students in these programs also increased. Approximately half of the increase in cost of attendance was offset by a $23 increase in institutional grants per 1 percentage point increase in share constrained (Table 7, column 3). This is consistent with colleges engaging in price discrimination: programs' sticker prices increased but students also received more grant aid. Aid received in the form of tuition waivers was unaffected.

We estimate IV models in which total federal loan aid is the endogenous regressor and $Pct_{p,pre} * Post_c$ serves as the excluded instrument.[47] Under the assumption that the baseline percent of students who were constrained only affected prices in the post period through changes in per-student federal loans, this specification provides an estimate of the extent to which prices changed per $1 increase in federal loans. Estimates suggest that $1 increase in federal loans

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program, these two results are not necessarily inconsistent. An increase in Grad PLUS borrowing and a decrease in Stafford borrowing could be explained by a change in the composition of students who borrow, with fewer students taking out federal loans overall but those who borrow taking on larger amounts.

[46] These estimates are not directly comparable to the estimates of Lucca et al. (2019) for the effect of exposure to undergraduate loan limit increases as Lucca et al. (2019) use a first differences model in which treatment is the interaction between the percent constrained exposure measure and the statutory increase in borrowing limits, separately for subsidized and unsubsidized loans.

[47] Total loans or Grad PLUS loans alone could also serve as the endogenous regressor in IV models. We focus on pricing responses to total federal loans because it is the most policy relevant measure of treatment – both Stafford and PLUS Loans are determined by the federal government, whereas private loans may adjust endogenously to these policy decisions.

resulted in a significant $1.10 increase in a program's list price and a $0.64 increase in net price (Table 8).

B. Robustness

We test the robustness of these results to the construction of the analysis sample, how exposure to Grad PLUS is measured, and weighting by baseline enrollment. Changing the minimum program size required for sample inclusion to 10 or 30 produces very similar results (Appendix Table A.11, Panels A and B). We explore several alternative measures of exposure to Grad PLUS. First, we replace $Pct_{p,pre}$ – the average percent constrained between 2003 and 2006 – with the percent of students who are constrained in 2006 alone (Panel C). This measure may have more measurement error in the true fraction constrained because fewer students are used to calculate it, but it is temporally closer to treatment. Second, we construct three additional measures of the baseline percent constrained: federal borrowing at the Stafford Loan annual maximum not accounting for partial year enrollment (Panel D), total borrowing at the Stafford maximum not accounting for partial year enrollment (Panel E), and federal borrowing at the Stafford maximum accounting for partial year enrollment (Panel F). Our results are similar across all these measures of treatment intensity.

We obtain similar (albeit less precise) estimated effects on borrowing, COA, and grants from a specification that discretizes the continuous measure of the percent of students constrained at baseline into a binary measure of above/below median baseline percent constrained to avoid issues with continuous differences in differences (Appendix Table A.11, Panel G). Results in Panel H show that our findings are similar when we do not weight observations by baseline program size. Results are also quite similar when we use alternative cut-offs to distinguish between academic and professional master's degree programs (Appendix Table B.3). Finally, we explore using a simulated instrument approach in which we also take into account the projected limit increase when estimating treatment effects $\left(i.e., Pct_{p,pre} * Post_c * LimInc_p\right)$. Appendix Table A.12 contains first stage and reduced form estimates and Table A.13 displays estimates from IV models, which are similar in magnitude to our main results but less precise.[48]

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[48] While the simulated instrument approach incorporates additional variation from the size of the expected limit increase, it also reduces variation for programs that have a $0 projected limit increase even though such programs with a large share of constrained students may still have an incentive to raise prices above the Stafford limit.

C. Price Discrimination

   Although prices may have gone up in response to the policy change, all students may not have borne the burden of tuition increases equally, given institutions' ability to price discriminate by offering discounts through grants and tuition waivers. Thus, we investigate the extent to which Grad PLUS-induced price increases affected the distribution of grants to students in different groups. We create a new data set at the program-by-year-by-group level, where group is defined by baseline student characteristics such as Pell Grant receipt as an undergraduate or race/ethnicity. Ex ante, it is not clear how price discrimination will work in graduate school, and while we observe income and assets for students (and their spouse, if present), this information will only be relevant for need-based (versus merit-based) aid. We consider several groups of students who may have experienced differential price discrimination. Groups are defined by student race (white, Black, Hispanic, API), parental education (students with a college educated parent versus first-generation college students), Pell Grant receipt as an undergraduate in Texas, and the federal government's measure of need (above versus below median EFC).

   Table 9 presents estimates by student race/ethnicity. We find some evidence of heterogeneous borrowing responses to Grad PLUS: Black students' federal loans increased by $91 per 1 percentage point increase in baseline percent constrained, Hispanic and white students' loans increased by $80 and $67 respectively, and Asian and Pacific Islander (API) students saw a $50 increase in average Grad PLUS loans. In contrast, we find the largest increase in average grant aid among white students, $34 per 1 percentage point increase in baseline percent constrained. Average grant aid increased by $27 for Hispanic and API students and $15 for Black students. These differences in grant aid translate into differences in net price. On average, Black students saw their net price increase by $36 per 1 percentage point increase in baseline exposure and Hispanic students saw a $15 increase. Increases in average net prices faced by white and API students were $7 and $8, respectively. None of the estimated effects on net price are statistically significant at conventional levels but are suggestive that pricing responses to Grad PLUS were not equally experienced by students of different races/ethnicities.

   Next, we examine whether there is heterogeneity in borrowing, grant, and price effects by measures of socioeconomic status (SES). Table 10 contains these results. Implied increases in grant aid are larger for non-Pell Grant recipients, students with a college educated parent, and

students with above median need, but differences between groups are smaller than those implied by estimated effects by race/ethnicity.

Taken together, the estimates in Tables 9 and 10 suggest that increases in grant aid were not targeted to underrepresented students or students from less advantaged backgrounds. We formally test whether increases in grants per $1 increase in federal loan aid were significantly larger for underrepresented groups by comparing the estimates from IV models. Table 11 contains these results. To compare effects on grants by race/ethnicity we combine Black and Hispanic students into a single category and white and API students into a second grouping. Estimates imply that average grants increased by $0.69 per $1 increase in federal loans for white and API students but only by $0.41 for Black and Hispanic students. The difference between these estimates is significant at the 10 percent level. Estimated effects by Pell Grant receipt, parental education, and EFC are not statistically distinguishable.

Overall, our results demonstrate that schools do in fact respond to increased loan access by increasing tuition, and it appears that this burden is not born disproportionately by higher-SES students nor were benefits targeted to students in groups that have been historically underrepresented in graduate school. While we test for heterogeneity in compensating increases in grant aid along dimensions of representation and need, we do not observe pre-graduate school academic preparation (such as GRE scores) or other measures upon which merit-based aid might be based, which in the case of graduate education, may be the most relevant dimension for price discrimination.[49]

7. Discussion and Conclusion

This paper explores the comprehensive effects of a large expansion in federal student loans for graduate school due to the creation of the federal Grad PLUS Program. Grad PLUS increased graduate student loans and shifted a portion of graduate borrowing from private to federal sources. However, the increase in federal loan limits did not increase access to graduate programs overall or for underrepresented students.

We find little evidence of economically significant short- or longer-run effects on educational attainment for students who were or would have been constrained by federal borrowing limits in the absence of Grad PLUS, even though cumulative debt significantly increased for these

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[49] Another relevant factor affecting changes in grant provision could be field of study, but our sample is too small to estimate heterogeneity along this dimension.

students when they gained access to Grad PLUS loans. This suggests that access to additional liquidity was not the binding constraint for graduate student borrowers' human capital investments prior to the implementation of Grad PLUS. We also find little evidence of an impact on later earnings, consistent with no change in human capital accumulation. This contrasts with the large human capital and earnings returns to higher loan limits among constrained undergraduates (Black et al 2020), who face relatively low federal borrowing limits and may have limited access to private student loans.

However, Grad PLUS-driven increases in federal student loans did significantly increase prices, confirming the Bennett Hypothesis. In addition to raising prices, we show that schools engaged in price discrimination more after the increase in student loan availability by increasing grant aid. As a result, increases in federal borrowing led to smaller increases in net prices than in the listed price. We find suggestive evidence that the increases in grant aid was larger for white and API students than for Black or Hispanic students, but otherwise did not vary by SES. It is important to note that only some graduate students borrow, but the price increases we find were also borne by nonborrowers.

Our results suggest that Grad PLUS loans primarily benefited institutions and programs that were able to charge higher prices. However, the program was established in an era with robust private student loan offerings and lenient underwriting standards (Consumer Financial Protection Bureau, 2012). As was the case with mortgage lending, the onset of the Great Recession led to substantial tightening of creditworthiness standards and contraction in private student loan availability. While our estimates of the effects of Grad PLUS do not appear to vary substantially before and after the start of the Great Recession, it is still possible that, given our evidence that students substituted from private to federal loans in response to Grad PLUS, effects on access and success would be different in a setting with limited access to private student loans.

Although historically, graduate student borrowers have been less likely to fall delinquent or default on their loan payments than those who borrowed as undergraduates (Looney and Yannelis 2015), in recent years loan repayment rates have fallen for both undergraduate and graduate borrowers. Our results raise important questions about the benefits of essentially uncapped government-backed loans for graduate school and the need for future research on the consequences of increased debt burdens for students who do not receive a commensurate rise in their human capital.

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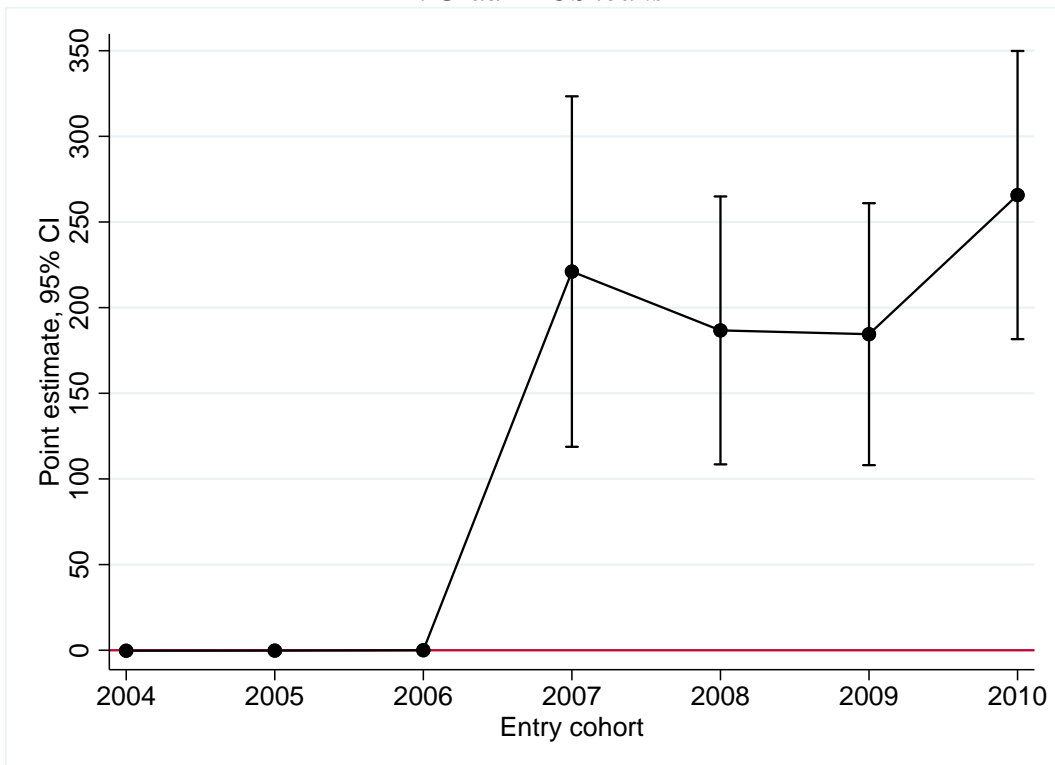Figure 1: Effect of a $1000 increase in loan limits on graduate program access
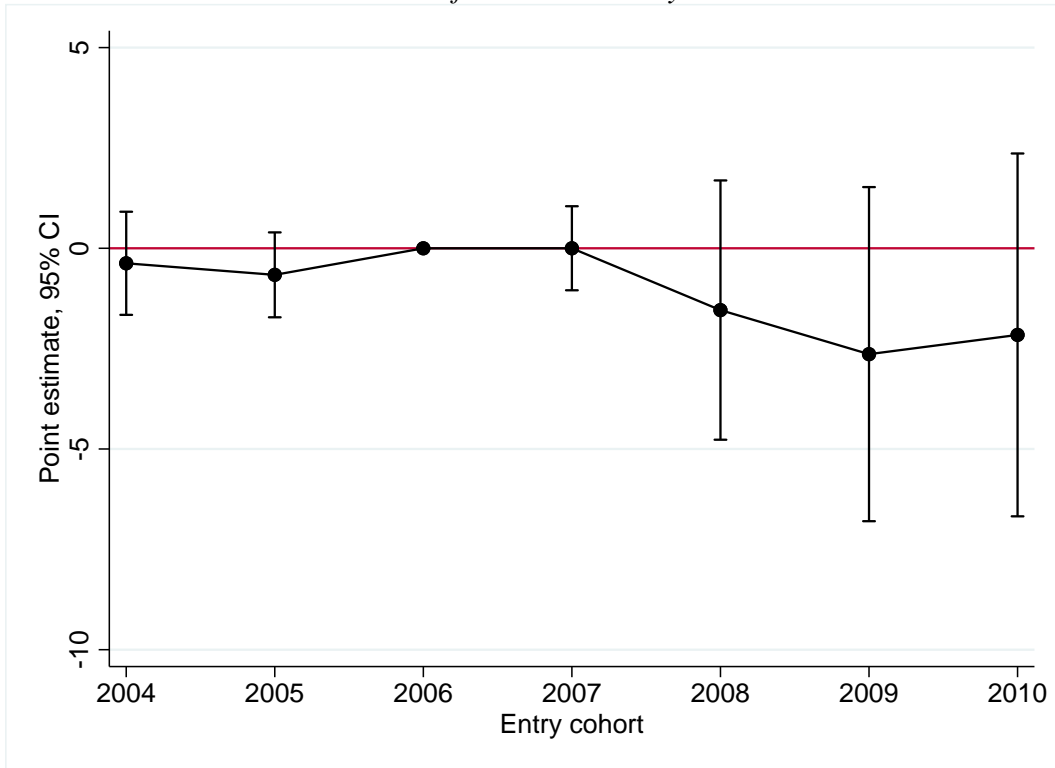

A. Federal borrowing limit
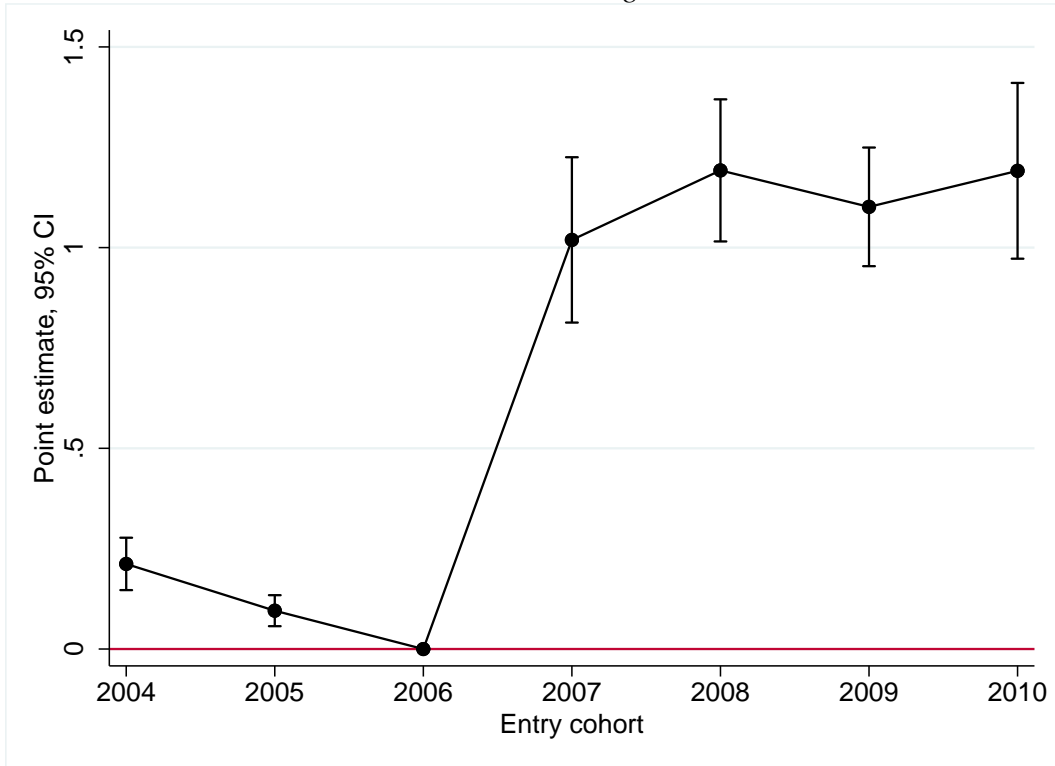
B. Grad PLUS loans

C. Number of students in entry cohort

D. Percent (0-100) of entering students who are Black, Hispanic, or Native American
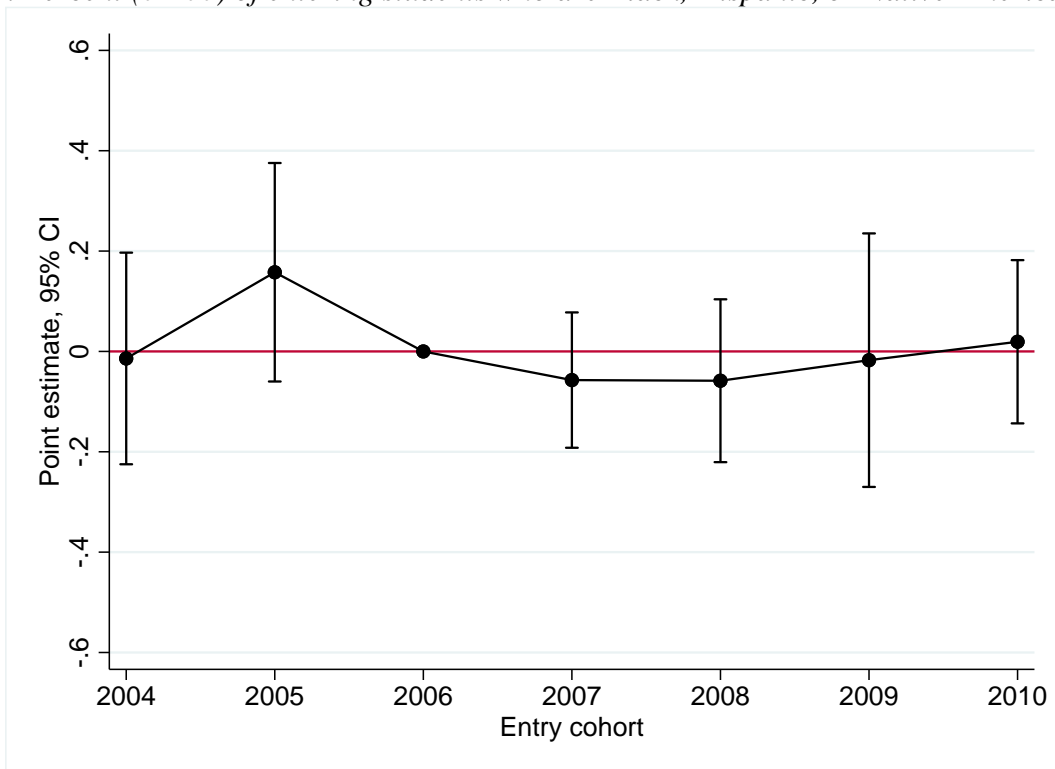
Figure 1, continued
E. Percent (0-100) of entering students who are men
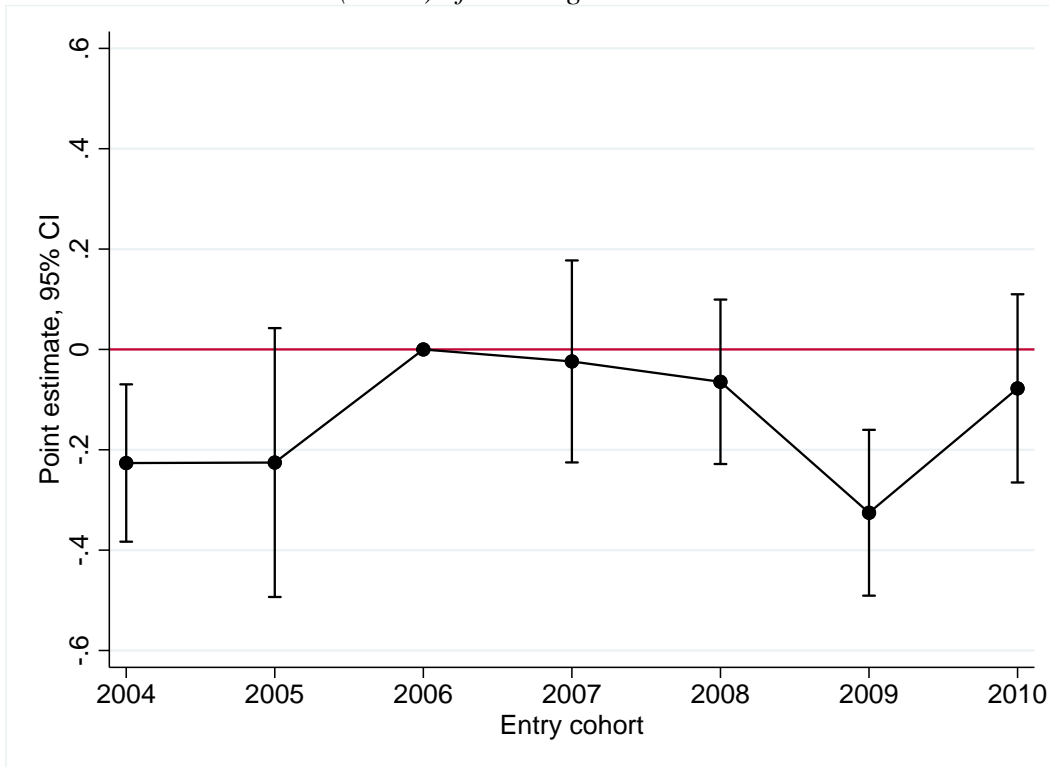
Notes: The sample includes graduate programs that had entering students in each of the 2004 through 2010 academic years and had at least 20 entering students who filed a FAFSA in 2004 through 2006. Point estimates and 95% confidence intervals from regressions of federal loan limits (Panel A), average Grad PLUS loans per student (Panel B) first-year enrollment (Panel C) or percent (0-100) of entering students who were Black, Hispanic, or Native American/Alaskan Native (Panel D), or men (Panel E) on an interaction between entry cohort and the projected federal loan limit increases (see text for details). Regressions also include entry cohort and program fixed effects. Standard errors are clustered at the program level.

Figure 2: Effects on constrained students' cumulative Grad PLUS loans by entry cohort
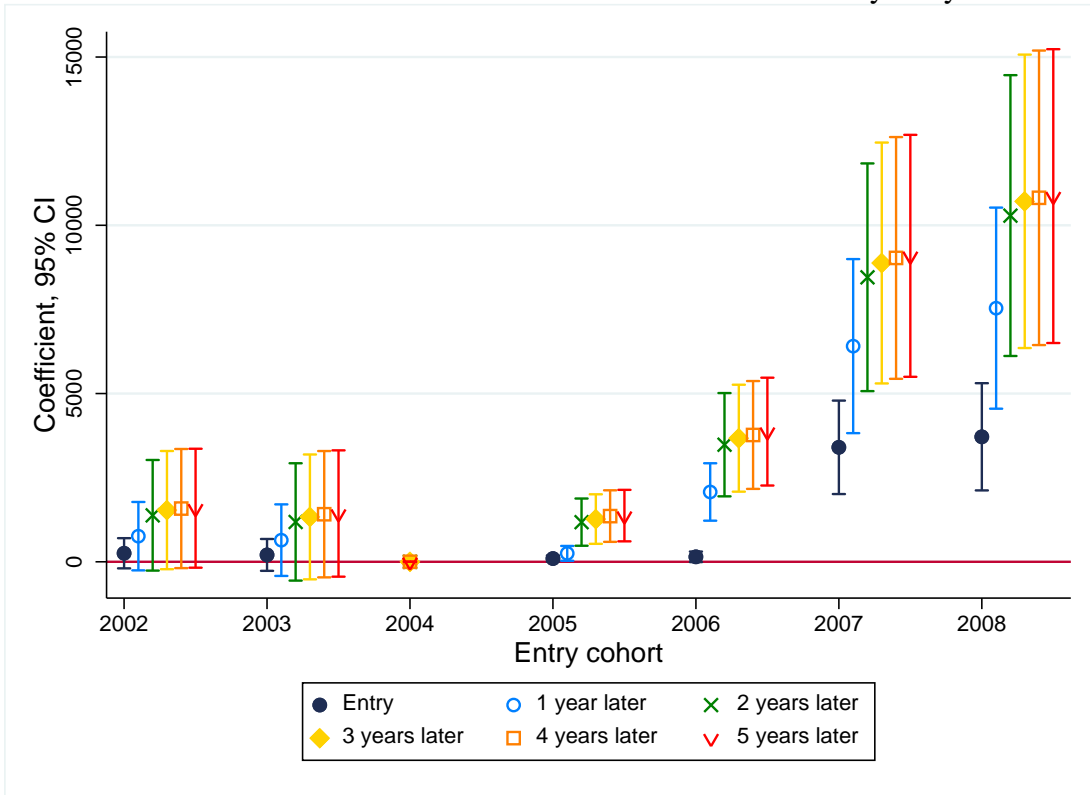
Notes: The sample includes first-time graduate students who borrowed in their first year of enrollment. Point estimates and 95% confidence intervals from regressions of cumulative Grad PLUS loans at the specified number of years since entry on an interaction between entry cohort and an indicator for being constrained (borrowing at the federal Stafford Loan limit). Regressions also include entry cohort and entry program fixed effects and age, indicators for race/ethnicity, gender, college educated parents and enrollment in fall and spring, and constrained. Standard errors are clustered at the program level.

Figure 3: Effects on constrained students' cumulative student loans from all sources
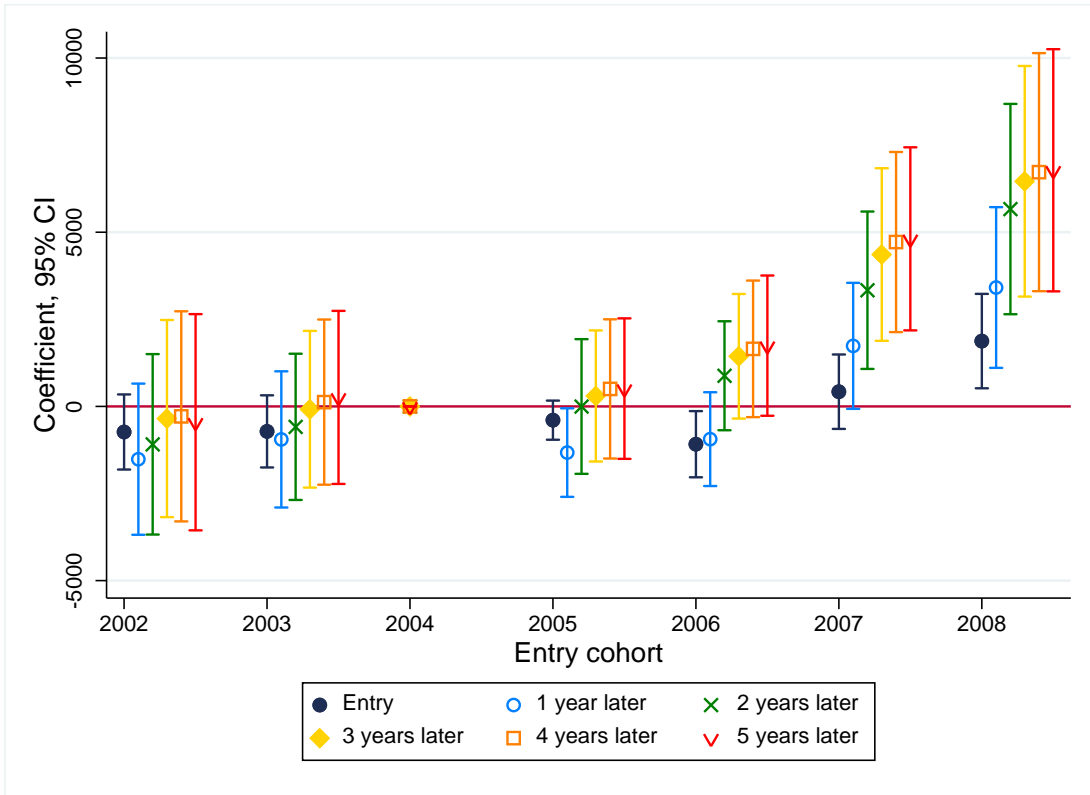
Notes: The sample includes first-time graduate students who borrowed in their first year of enrollment. Point estimates and 95% confidence intervals from regressions of cumulative student loans at the specified number of years since entry on an interaction between entry cohort and an indicator for being constrained (borrowing at the federal Stafford Loan limit). Regressions also include entry cohort and entry program fixed effects and age, indicators for race/ethnicity, gender, college educated parents and enrollment in fall and spring, and constrained. Standard errors are clustered at the program level.

Figure 4: Effects on constrained students' degree receipt by entry cohort

Notes: The sample includes first-time graduate students who borrowed in their first year of enrollment. Point estimates and 95% confidence intervals from regressions of the probability of any graduate credential receipt as of the specified number of years since entry on an interaction between entry cohort and an indicator for being constrained (borrowing at the federal Stafford Loan limit). Regressions also include entry cohort and entry program fixed effects and age, indicators for race/ethnicity, gender, college educated parents and enrollment in fall and spring, and constrained. Standard errors are clustered at the program level.

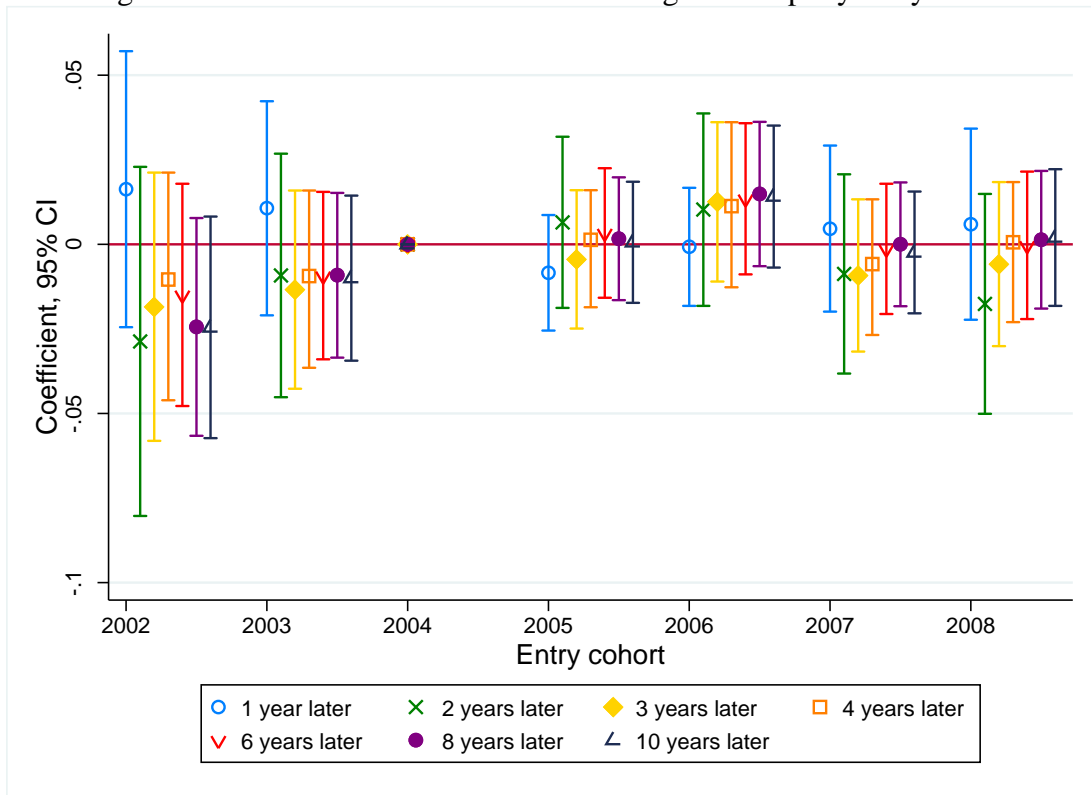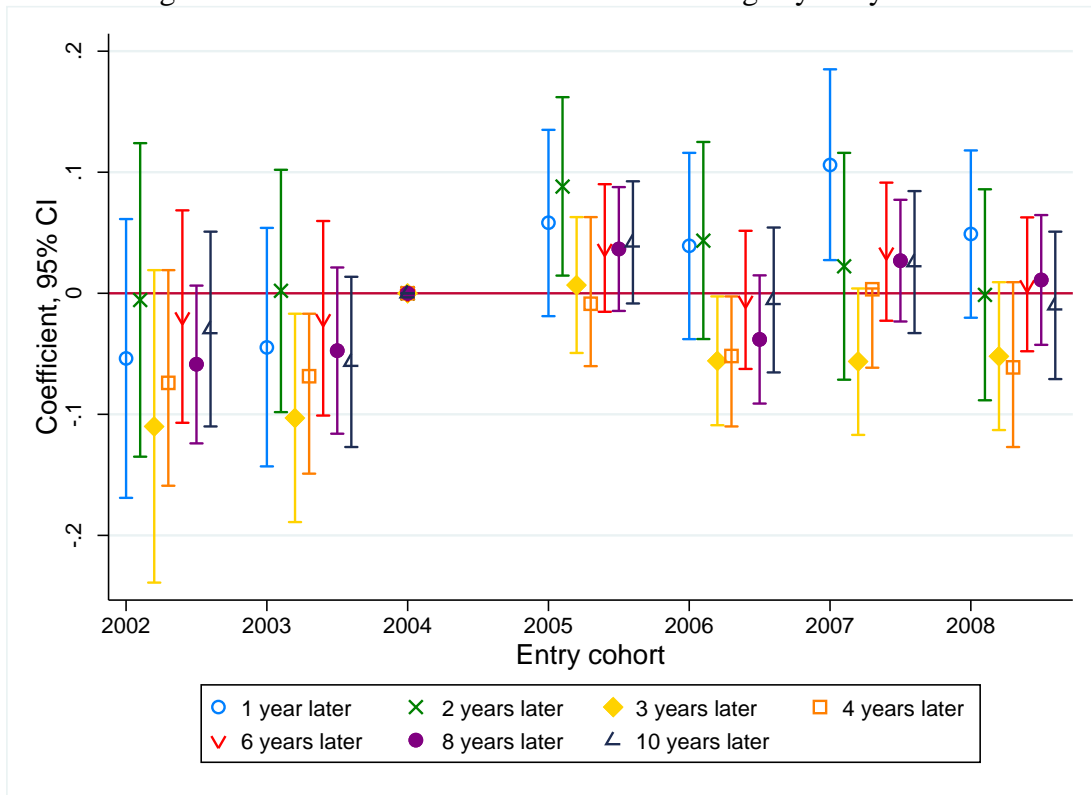Figure 5: Effect on constrained students' earnings by entry cohort

Notes: The sample includes first-time graduate students who borrowed in their first year of enrollment. Point estimates and 95% confidence intervals from regressions of ln(annual earnings) at the specified number of years since entry on an interaction between entry cohort and an indicator for being constrained (borrowing at the federal Stafford Loan limit). Regressions also include entry cohort and entry program fixed effects and age, indicators for race/ethnicity, gender, college educated parents and enrollment in fall and spring, and constrained. Standard errors are clustered at the program level.

Figure 6: Effect of a 1 percentage point increase in baseline percent of students who are constrained by Stafford Loan limits on program-level borrowing and prices
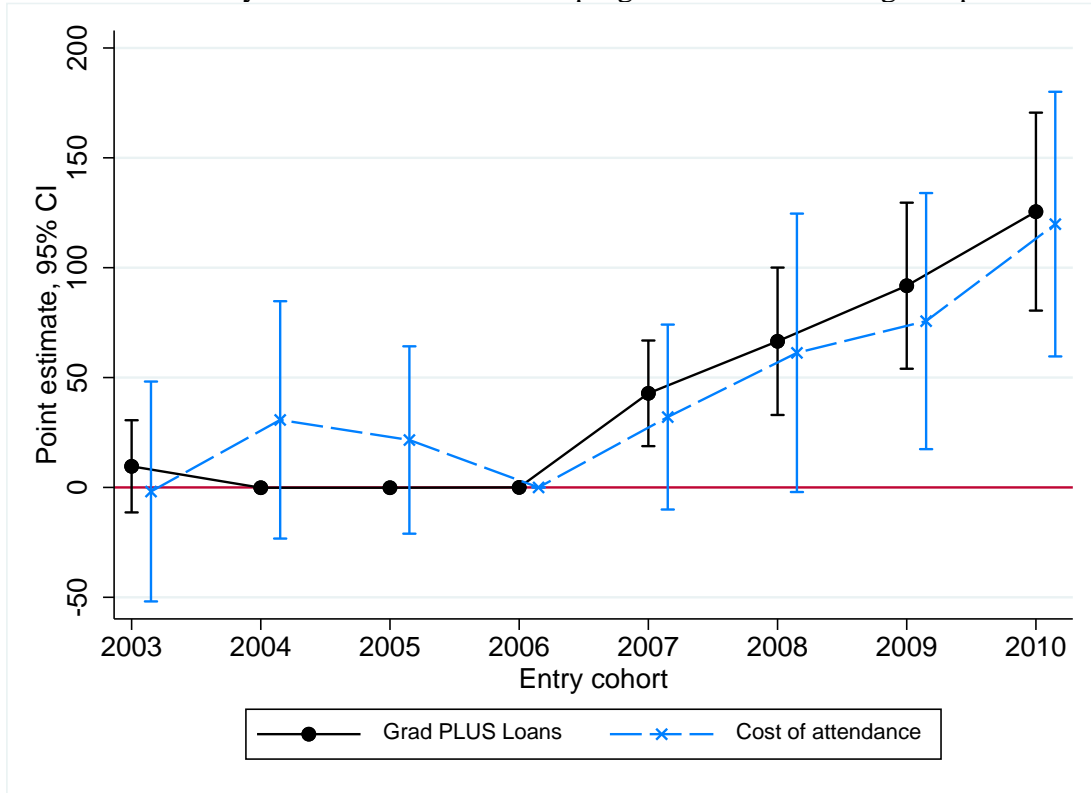
Notes: The sample includes a balanced panel graduate programs with enrollment in the 2003 through 2010 academic years and at least 20 federal aid recipients enrolled per year, on average, between 2003 and 2006. Point estimates and 95% confidence intervals from regressions of average Grad PLUS loans per student (dark solid markers) or average cost of attendance (light Xs) on interactions between academic year indicators and the percent of students who were constrained at baseline (see text for definition). Regressions also include academic year and program fixed effects. Standard errors are clustered at the program level.

Table 1: Characteristics of first-time graduate students

	(1) Pre-Grad PLUS (2002-2006)	(2) Post Grad PLUS (2007-2010)	(3) All
Observations	246,057	212,674	458,731
Female	0.58	0.58	0.58
Race/ethnicity/nativity[1]			
Asian	0.06	0.06	0.06
Black	0.10	0.10	0.10
Hispanic	0.16	0.16	0.16
White	0.55	0.53	0.54
International	0.13	0.13	0.13
Age (in yrs.)	30	29	30
Texas Resident[2]	0.77	0.77	0.77
Degree receipt within			
2 years	0.44	0.51	0.47
4 years	0.63	0.69	0.66
6 years	0.67	0.74	0.70
8 years	0.69	0.75	0.72
Broad field of study			
Education	0.21	0.20	0.21
Business	0.12	0.13	0.12
Health	0.12	0.13	0.13
Engineering	0.06	0.06	0.06
Law	0.05	0.04	0.04
Computer science	0.03	0.02	0.02
Academic doctoral	0.14	0.13	0.14
Borrowers	0.32	0.40	0.36
Constrained borrowers	0.10	0.16	0.12
Amount borrowed (2018$)			
Total loans	$5,637	$7,459	$6,482
Federal Stafford loans	$5,237	$6,565	$5,852
Federal PLUS loans	$13	$597	$284
Federal Perkins loans	$82	$49	$67
State loans	$17	$50	$32
Private and other loans	$289	$198	$246
Total grants (2018$)	$734	$1,551	$1,113
Cost of Attendance (2018$)[3]	$26,064	$29,940	$28,270

Notes: Sample is limited to first-time graduate students who enrolled in the 2002 through 2010 academic years. Constrained borrowers are students who borrowed the maximum available Stafford Loan amount for the academic year. Standard deviations for continuous variables under means in parentheses.
  1. Among those in one of the listed race/ethnicity/nativity categories (pre N = 239,627; post N = 195,383).
  2. Among those with nonmissing residency information (pre N = 213,611; post N = 171,990).
  3. Among those with nonmissing COA (i.e., who filed a FAFSA) (pre N = 82,738; post N = 109,321).

Table 2: Effect of projected and realized increases in federal loan limits on enrollment and the composition of entering graduate students

	(1) Enrollment	Percent (0-100%) of entering students who are:					
		(2) Black	(3) Hispanic	(4) API	(5) White	(6) Internl	(7) Men
A.OLS estimates							
Projected limit increase ($1k) x Post	-1.2	-0.04	-0.03	0.05	0.39	-0.15	0.03
	(1.5)	(0.05)	(0.05)	(0.04)	(0.144)**	(0.159)	(0.074)
B. IV estimates							
Federal loan limit ($1k)	-1.3	-0.04	-0.03	0.05	0.38	-0.14	0.03
	(1.4)	(0.04)	(0.05)	(0.04)	(0.118)**	(0.14)	(0.07)
95% CI	[-4.1 ,1.5]	[-0.12 ,0.04]	[-0.12 ,0.06]	[-0.02 ,0.12]	[0.15 ,0.61]	[-0.42 ,0.13]	[-0.11 ,0.16]
C. Pre-Grad PLUS mean	131.3	8.2	16.8	5.8	53.9	12.9	40.8

Notes: The sample includes graduate programs that had entering students in each of the 2004 through 2010 academic years and had at least 20 entering students who filed a FAFSA in 2004 through 2006 (N = 2,345). Panel A displays point estimates from regressions of first-year enrollment or percentage of entering students (0-100) with the given demographic characteristic on an interaction between post-Grad PLUS entry cohort and the projected federal loan limit increases (see text for details). Panel B displays point estimates from instrumental variables models in which the interaction between the projected limit increase and the indicator for post-Grad PLUS serves as the excluded instrument for the realized federal loan limit (F-stat = 171). Panel C displays the mean of the dependent variable in 2004-2006. All specifications also include entry cohort and program fixed effects. Columns (2) through (7) estimates weighted by the size of the entering cohort. Robust standard errors, clustered at the program level, in parentheses; ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table 3: The effect of Grad PLUS on constrained students' cumulative borrowing

Years since entry =	0	1	2	3	4	5	6
A. Federal PLUS loans							
Constrained x treated cohort	1796	3860	5404	5622	5702	5752	5772
	(358)**	(781)**	(1122)**	(1152)**	(1153)**	(1152)**	(1151)**
Dep var mean (const, pre-period)	$12	$14	$19	$88	$133	$171	$226
B. Federal loans (Stafford + PLUS)							
Constrained x treated cohort	1054	2870	5338	5909	6099	6144	6159
	(397)**	(814)**	(1188)**	(1342)**	(1401)**	(1433)**	(1460)**
Dep var mean (const, pre-period)	$23,254	$42,038	$53,282	$56,729	$58,331	$59,401	$60,196
C. State and private loans							
Constrained x treated cohort	-504	-1587	-2417	-2595	-2592	-2581	-2578
	(235)*	(544)**	(770)**	(837)**	(834)**	(832)**	(831)**
Dep var mean (const, pre-period)	$2,226	$4,399	$5,489	$5,609	$5,653	$5,673	$5,682
D. Total loans							
Constrained x treated cohort	575	1347	2926	3325	3519	3579	3596
	(344)+	(629)*	(860)**	(956)**	(1011)**	(1034)**	(1058)**
Dep var mean (const, pre-period)	$25,704	$46,958	$59,607	$63,258	$64,924	$66,020	$66,829

Notes: The sample includes first-time graduate students in the 2002 through 2008 entry cohorts who borrowed in their first year of enrollment. Point estimates from regressions of cumulative student loans at the specified number of years since entry on an interaction between an indicator for being constrained (borrowing at the federal Stafford Loan limit) and an indicator for belonging to a treated cohort (academic year 2005 and later). Regressions also include entry cohort and entry program fixed effects and age, indicators for race/ethnicity, gender, college educated parents and enrollment in fall and spring, and constrained. Robust standard errors, clustered at the program level, in parentheses; ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table 4: The effect of Grad PLUS on constrained students' educational attainment

Years since entry =	1	2	3	4	5	6	7	8	9	10
A. Cumulative years enrolled										
Constrained x treated cohort	0.010	0.022	0.026	0.041	0.048	0.053	0.054	0.053	0.051	0.048
	(0.006)	(0.017)	(0.023)	(0.028)	(0.033)	(0.036)	(0.039)	(0.041)	(0.043)	(0.044)
Dep var mean (const, pre-period)	1.88	2.48	2.69	2.80	2.89	2.96	3.02	3.06	3.10	3.14
B. Cumulative credit hours attempted										
Constrained x treated cohort	0.345	0.98	1.142	1.32	1.469	1.572	1.593	1.605	1.605	1.588
	(0.425)	(0.496)*	(0.630)+	(0.667)*	(0.690)*	(0.715)*	(0.734)*	(0.750)*	(0.761)*	(0.766)*
Dep var mean (const, pre-period)	32.80	41.08	43.39	44.79	45.79	46.55	47.17	47.66	48.06	48.40
C. Any graduate degree receipt										
Constrained x treated cohort	-0.005	0.005	0.005	0.006	0.008	0.009	0.011	0.012	0.012	0.011
	(0.013)	(0.012)	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Dep var mean (const, pre-period)	0.280	0.675	0.769	0.799	0.813	0.822	0.827	0.831	0.835	0.837

Notes: The sample includes first-time graduate students in the 2002 through 2008 entry cohorts who borrowed in their first year of enrollment. Point estimates from regressions of cumulative years of enrollment (Panel A), cumulative credit hours attempted (Panel B), or the probability of any degree receipt (Panel C) as of the specified number of years since entry on an interaction between an indicator for being constrained (borrowing at the federal Stafford Loan limit) and an indicator for belonging to a treated cohort (academic year 2005 and later). Regressions also include entry cohort and entry program fixed effects and age, indicators for race/ethnicity, gender, college educated parents and enrollment in fall and spring, and constrained. Robust standard errors, clustered at the program level, in parentheses; * $p < 0.05$, + $p < 0.1$.

Table 5: The effect of Grad PLUS on constrained students' labor market outcomes

Years since entry =	1	2	3	4	5	6	7	8	9	10
A. Any earnings (N = 117,954)										
Constrained x treated cohort	0.012	0.020	0.016	0.015	0.015	0.015	0.012	0.011	0.012	0.013
	(0.009)	(0.008)*	(0.008)*	(0.007)*	(0.007)*	(0.008)+	(0.008)	(0.008)	(0.009)	(0.008)
Dep var mean (const, pre-period)	0.717	0.706	0.712	0.69	0.669	0.651	0.637	0.624	0.614	0.605
B. Ln(earnings)										
Constrained x treated cohort	0.086	0.038	0.009	0.003	-0.005	0.028	0.035	0.033	0.024	0.033
	(0.028)**	(0.035)	(0.024)	(0.025)	(0.020)	(0.020)	(0.019)+	(0.019)+	(0.017)	(0.022)
Dep var mean (const, pre-period)	9.67	10.01	10.57	10.81	10.89	10.95	10.99	11.03	11.08	11.09
Observations	87,587	85,519	88,277	86,146	84,122	82,424	80,816	79,539	78,309	77,347

Notes: The sample includes first-time graduate students in the 2002 through 2008 entry cohorts who borrowed in their first year of enrollment. Point estimates from regressions of the probability of having earnings in a UI-covered sector in Texas (Panel A) or ln(annual earnings) as of the specified number of years since entry on an interaction between an indicator for being constrained (borrowing at the federal Stafford Loan limit) and an indicator for belonging to a treated cohort (academic year 2005 and later). Regressions also include entry cohort and entry program fixed effects and age, indicators for race/ethnicity, gender, college educated parents and enrollment in fall and spring, and constrained. Robust standard errors, clustered at the program level, in parentheses; ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table 6: Effect of 1 pp increase in baseline percent of students constrained by Stafford Loan limit on average per-student loans

	(1) Grad PLUS	(2) Total Federal	(3) State	(4) Private
% constrained*Post	79.3	54.3	3.3	-33.1
	(16.6)**	(28.8)+	(3.2)	(12.3)**
Observations	2,336	2,336	2,336	2,336

Notes: The sample includes a balanced panel graduate programs with enrollment in the 2003 through 2010 academic years and at least 20 federal aid recipients enrolled per year, on average, between 2003 and 2006. Point estimates from regressions of average loans per student from the specified source on an interaction between post-Grad PLUS and the percent of students who were constrained at baseline (see text for definition). Regressions also include academic year and program fixed effects. Robust standard errors, clustered at the program level, in parentheses; ** $p < 0.01$, + $p < 0.1$.

Table 7: Effect of 1 pp increase in baseline percent of students constrained by Stafford Loan limit on program prices and financial aid

	(1) COA	(2) FTFY COA	(3) Grants	(4) Tuit waivers	(5) Net price
% constrained*Post	59.6	62.7	23.0	1.8	34.8
	(21.1)**	(18.9)**	(13.7)+	(3.1)	(30.2)
Observations	2,336	2,336	2,336	2,336	2,336

Notes: The sample includes a balanced panel graduate programs with enrollment in the 2003 through 2010 academic years and at least 20 federal aid recipients enrolled per year, on average, between 2003 and 2006. Point estimates from regressions of average prices or average aid per student (indicated in the column heading) on an interaction between post-Grad PLUS and the percent of students who were constrained at baseline (see text for definition). COA = cost of attendance. FTFY COA is the predicted program-level cost of attendance for a full-time, full-year student (see text for details). Net price equals COA minus grants and tuition waivers. Regressions also include academic year and program fixed effects. COA = cost of attendance. Net price equals COA minus grants and tuition waivers. Robust standard errors, clustered at the program level, in parentheses; ** $p < 0.01$, + $p < 0.1$.

Table 8: IV estimates of the effect of federal loans on program price

	(1) COA	(2) FTFY COA	(3) Net price
Federal loans	1.098	1.156	0.641
	(0.480)*	(0.5181)*	(0.355)+
Observations	2,336	2,336	2,336

Notes: The sample includes a balanced panel graduate programs with enrollment in the 2003 through 2010 academic years and at least 20 federal aid recipients enrolled per year, on average, between 2003 and 2006. Point estimates from instrumental variables models in which average federal student loans per student is the endogenous regressor and an interaction between post-Grad PLUS and the percent of students who were constrained at baseline (see text for definition) is the excluded instrument. Regressions also include academic year and program fixed effects. COA = cost of attendance. Net price equals COA minus grants and tuition waivers. Robust standard errors, clustered at the program level, in parentheses; * $p < 0.05$, + $p < 0.1$.

Table 9: Heterogeneity in the effect of exposure to Grad PLUS by race/ethnicity

	(1) Grad PLUS loans	(2) Total Fed. loans	(3) Grants	(4) Net price
A. Asian or Pacific Islander				
% constrained*Post	49.8	18.4	26.5	8.3
	(11.7)**	(17.7)	(15.2)+	(35.0)
Observations	1,770	1,770	1,770	1,770
B. Black				
% constrained*Post	91.4	55.4	15.1	35.5
	(20.0)**	(21.4)*	(28.6)	(40.7)
Observations	2,111	2,111	2,111	2,111
C. Hispanic				
% constrained*Post	79.5	13.2	26.6	14.8
	(18.7)**	(26.2)	(20.3)	(38.6)
Observations	2,240	2,240	2,240	2,240
D. White				
% constrained*Post	66.7	20.2	33.6	7.0
	(14.7)**	(15.5)	(17.4)+	(40.0)
Observations	2,286	2,286	2,286	2,286

Notes: The sample includes a balanced panel graduate programs with enrollment in the 2003 through 2010 academic years and at least 20 federal aid recipients enrolled per year, on average, between 2003 and 2006. Programs without any students of the specified race/ethnicity are excluded. Point estimates from regressions of average loans, grants, or price per student on an interaction between post-Grad PLUS and the percent of students who were constrained at baseline (see text for definition). Net price equals COA minus grants and tuition waivers. Regressions also include academic year and program fixed effects. Robust standard errors, clustered at the program level, in parentheses; ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table 10: Heterogeneity in the effect of exposure to Grad PLUS by socioeconomic status

	(1) Grad PLUS loans	(2) Total Fed. loans	(2) Grants	(4) Net price
A. Received Pell Grant as undergrad				
% constrained*Post	103.7	66.5	19.2	18.7
	(23.0)**	(36.2)+	(20.2)	(32.4)
Observations	2,319	2,319	2,319	2,319
B. Did not receive Pell as undergrad				
% constrained*Post	85.3	70.1	25.5	33.1
	(18.0)**	(32.5)*	(15.5)	(33.9)
Observations	2,336	2,336	2,336	2,336
C. First generation college student				
% constrained*Post	94	75.6	24.8	36.9
	(20.4)**	(36.3)*	(19.7)	(35.4)
Observations	2,336	2,336	2,336	2,336
D. College educated parent				
% constrained*Post	103.3	75.4	27.8	29.7
	(20.2)**	(36.3)*	(18.5)	(35.5)
Observations	2,319	2,319	2,319	2,319
E. EFC < median				
% constrained*Post	100.1	81.3	26.6	37.4
	(21.4)**	(35.7)*	(18.6)	(35.3)
Observations	2,334	2,334	2,334	2,334
F. EFC > median				
% constrained*Post	89.6	65.8	26.5	13.8
	(19.4)**	(34.2)+	(17.6)	(28.7)
Observations	2,327	2,327	2,327	2,327

Notes: The sample includes a balanced panel graduate programs with enrollment in the 2003 through 2010 academic years and at least 20 federal aid recipients enrolled per year, on average, between 2003 and 2006. Programs without any students of the specified category are excluded. EFC = expected family contribution (limited to students who filed an application for federal student aid). Undergraduate Pell Grant receipt only available for students who received an undergraduate degree from a Texas public higher education institution. Point estimates from regressions of average loans, grants, or price per student on an interaction between post-Grad PLUS and the percent of students who were constrained at baseline (see text for definition). Net price equals COA minus grants and tuition waivers. Regressions also include academic year and program fixed effects. Robust standard errors, clustered at the program level, in parentheses; ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table 11: Heterogeneity in the effect of federal borrowing on average grant aid received by students within demographic groups

	(1) URM (vs. White/API)	(2) Pell receipt as UG	(3) First gen student	(4) EFC > median
Federal loans				
x Has characteristic	0.407	0.289	0.369	0.402
	(0.535)	(0.400)	(0.374)	(0.405)
x Does not have characteristic	0.689	0.364	0.329	0.327
	(0.612)	(0.343)	(0.358)	(0.325)
Test of eq (p-val)	0.063	0.513	0.584	0.514
Observations	4,614	4,655	4,655	4,661

Notes: See Table 10 notes for sample. Programs without any students of the specified groups are excluded. EFC = expected family contribution (limited to students who filed an application for federal student aid). Undergraduate Pell Grant receipt only available for students who received an undergraduate degree from a Texas public higher education institution. Point estimates from regressions of average grant aid per student on average federal loans per student from IV models in which an interaction between post-Grad PLUS and the percent of students who were constrained at baseline serves as excluded instruments. Regressions also include academic year and program fixed effects. Robust standard errors, clustered at the program level, in parentheses; ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.