PLUS or Minus?
The Effect of Graduate School Loans on Access, Attainment, and Prices*

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Abstract

In recent years, graduate students received over half of new student loan dollars, suggesting that they are important stakeholders when thinking about student debt in the United States. In 2006, the federal government effectively uncapped student borrowing for graduate programs with the introduction of the Graduate PLUS loan program. The increase in borrowing limits did not increase enrollment in existing programs overall or for underrepresented groups. Access to additional federal loans did increase graduate students' borrowing and shifted the composition of their loans from private to federal debt. We document that among programs in which a larger share of graduate students were constrained by pre-Grad PLUS loan limits, and thus more exposed to the expansion in access to credit, federal borrowing and prices increased. Although access to additional loan aid may have increased constrained students' consumption smoothing, it did not lead to significant increases in their students' persistence or degree receipt.

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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 (U.S. Census Bureau 2019; 2022). 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; in the 2024-25 academic year, over half of all new loan dollars were disbursed to graduate students (U.S. Department of Education 2025). Despite the importance of student debt for graduate students and implications for the federal loan portfolio, there is limited causal evidence on whether graduate students are helped or harmed by student loans, and the extent to which student loan generosity has unintended spillovers on institutions' 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. 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 the private market (Friedman 1955). A sizeable empirical literature provides evidence on the presence and importance of credit constraints for undergraduate students.[1] 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 students and institutions. 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 years prior to the creation

[1] 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).

of Grad PLUS, almost 4 out of 10 graduate students with federal loans were borrowing at the existing limit (Woo and Shaw 2015). While essentially all graduate students gained access to Grad PLUS loans, some students and programs stood to benefit more, namely prospective students seeking to attend programs with prices above the pre-Grad PLUS limit who faced higher borrowing costs and/or lack of access to private student loans, programs in which many students had exhausted their federal loan eligibility, and enrolled students constrained by pre-Grad PLUS limits. We take advantage of this 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, which is notable because private student loans often have worse terms than federal loans (Consumer Financial Protection Bureau 2012). Yet, the increase in loan limits due to Grad PLUS did not increase enrollment in existing graduate programs; this is even true for low socioeconomic status (SES) and other underrepresented students who may have fewer alternative sources of financing for graduate education. However, Grad PLUS led to significantly higher program prices, particularly at programs that had less capacity to expand enrollment. Finally, although enrolled students who were constrained by federal borrowing limits increased the amount they borrowed when they gained access to higher loan limits through Grad PLUS, we find little evidence of economically significant increases in persistence or degree receipt.

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. However, Grad PLUS did not increase borrowing limits for programs with costs of attendance below the pre-Grad PLUS max. We leverage variation in whether and how much the new federal loan 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. We find that 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 0.5 student increase in enrollment (0.3 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 all but very small positive effects on the percentage of entering students who were Black or Hispanic. Although there was a small increase in the number of new programs created in post-Grad PLUS years, school-level estimates of the effect of higher loan limits are similarly null, suggesting that the creation of new programs after Grad PLUS led to no more than negligible increases in access.

Expanded federal loan generosity may also have unintended consequences if programs increase 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).[2] Other work has examined student-level price 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 higher loan limits led to increases in federal loan aid and tuition.

We use an identification strategy 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.[3] Student-level data allows for

[2] 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.

[3] 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 in an interrupted time-series design and does not find evidence of a significant break in the growth rate of prices. The interrupted time-series design cannot account for other time-varying shocks around the creation of Grad PLUS that may have also affected pricing decisions (e.g., changes in economic conditions during the Great Recession). 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. 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). In contrast, our identification strategy which relies on variation in exposure to higher loan limits, can account for aggregate shocks occurring concurrently with the creation of Grad PLUS and does not use undergraduate programs as a counterfactual.

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 who exhausted their federal loan eligibility in years preceding Grad PLUS. Indeed, after the introduction of Grad PLUS, these programs saw relatively larger increases in federal borrowing. We also find evidence of larger price increases among programs more exposed to Grad PLUS. Taken together, our estimates suggest that sticker prices went up approximately dollar for dollar with increases in per-student federal loans.

Our setting also allows us to test whether the additional revenue from higher prices was reinvested 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.

In our final set of analyses, we examine how increases in loan limits affected outcomes of enrolled students who were more likely to be constrained in their access to additional student loan aid in the absence of Grad PLUS. 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 did not exhaust their federal loan eligibility. Based on this intuition, our research design compares 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.

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. 2023), we find no evidence that Grad PLUS affected constrained graduate students' persistence or degree receipt.[4]

Prior work on the Bennett Hypothesis has not been able to trace out the full effects of policies that increase student aid, making it difficult to fully understand the welfare consequences of any corresponding price increases. As an example, Lucca, Nadauld, and Shen (2019) show that higher undergraduate loan limits increased prices but Black et al. (2023) showed that this increase in loan limits also increased constrained students' degree receipt and earnings. By considering effects on both human capital and prices, our paper provides a more complete view of the introduction of a large, publicly funded loan program. The null estimated effects on enrollment and attainment 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.

We interpret our findings through a simple conceptual framework in which programs vary in their baseline prices and ease of offering additional seats and at least some prospective students are constrained in their access to alternative sources of financing prior to Grad PLUS. This simple framework informs our identification strategies and provides testable predictions concerning heterogeneity in the effect of Grad PLUS across programs, namely that the elasticity of supply is a key determinant of programs' pricing and enrollment responses. We develop proxies for supply elasticity and find suggestive, albeit imprecise, evidence that programs with less elastic supply have larger price responses to Grad PLUS-driven increases in federal borrowing.

2. Setting and policy environment

Student loans represent the main source of federal student aid available to graduate students. To access federal loans, prospective graduate students must fill out the free application for federal student aid (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 graduate student loans does not depend on a student's EFC. Federal loan

[4] 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).

limits and interest rates are set by statute and, unlike private student loans, are not linked to borrower creditworthiness.[5]

2.1 Federal loan programs for graduate students

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.[6] Some health professional programs had higher limits.[7] Students attending programs with a cost of attendance below the Stafford Loan limit could only borrow up to the cost of attendance. 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 such as parental support (Lochner, Stinebrickner, and Suleymanoglu 2021; Bhargava et al. 2025).[8] Graduate students also faced lifetime limits on Stafford Loans – $138,500 for most programs – which include amounts borrowed for their undergraduate degree. Given that undergraduate borrowers faced an aggregate limit of $46,000, graduate students in most programs would still be eligible to borrow up to 5 years at the annual limit before exhausting their Stafford Loan lifetime limits in graduate school.

Since the 2006-07 academic year, students have had an additional federal loan option. 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. Grad PLUS loans had higher origination fees and interest rates compared to Stafford Loans, but also often had lower interest rates and repayment options (including plans that could offer forgiveness after a set number of qualifying payments) and were more accessible than private student loans (Consumer Financial Protection Bureau 2012). Stafford Loan limits also increased by $2,000. The Grad PLUS Program allowed a student to borrow up to the total

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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] 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.

[7] Medical students (including those studying osteopathic medicine, dentistry, veterinary medicine, and optometry) could borrow an additional $20,000 per academic year in Stafford Loans while students in public health, health administration, pharmacy, clinical psychology, and chiropractic graduate programs could borrow an additional $12,500 per academic year. The aggregate Stafford Loan limit (including undergraduate borrowing) for these health professions students was $189,125. See Hegji (2021), Appendix C for additional details.

[8] Only 5 percent of graduate students reported relying on friends or family members other than a spouse (i.e., parents) to pay for tuition or living expenses (authors’ calculations using the 2012 National Postsecondary Student Aid Study).

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 institution-owned housing.[9] However, tuition charges 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 programs' pricing decisions. Between 2007 and 2010, total Grad PLUS disbursements grew from $44 to $102 million.

2.2 Conceptual Framework

We start with a simple framework in which graduate programs supply seats and prospective graduate students demand seats at a given price, and the intersection of these curves determines equilibrium prices and quantities (i.e., enrollment). In the pre-Grad PLUS era, graduate students could fully cover program costs up to the Stafford Loan borrowing limit with federal student loans. For costs above this limit, some prospective students would face a higher cost of borrowing in the private student loan market or would be denied access altogether, resulting in a kink in their individual demand curves at the federal loan maximum. At the same time, some prospective students would be able to access funds at interest rates similar to those of federal student loans—these students are relatively unconstrained in their decision-making, and their individual demand curve would not feature a kink. In Figure 1, the market demand curve, D_0, features a kink at the pre-Grad PLUS federal student loan borrowing limit, and the magnitude of the kink is determined by the relative share of constrained individuals in the population of prospective graduate students and the interest rate differential between market interest rates and the rates constrained students would face in the private loan market.

There are a variety of types of programs in the market, some with a more elastic supply of seats than others. We consider two types of programs – those with perfectly inelastic supply (Figure 1, Panels A and B) and those with more elastic supply (Panel C and D). Programs are

[9] 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.

further distinguished by whether baseline prices were above or below the pre-Grad PLUS federal borrowing limit, which could be due to differences in the fixed cost of offering a program. In this case, programs with lower fixed costs have prices below the pre-Grad PLUS federal loan maximum (Panels A and C) and those with higher fixed costs have prices above the baseline federal loan limit (Panels B and D). Prior to the creation of Grad PLUS, E_0 graduate students will enroll in each type of program and pay T_0.

The introduction of Grad PLUS allows all students to access federal student loans up to the total cost of attendance at the same interest rates as federal loans, eliminating the kink in the post-Grad PLUS demand curve (D_1). Figure 1 illustrates how the effect of Grad PLUS on enrollment and prices will depend on both the elasticity of supply of seats as well as baseline tuition. For programs with baseline below pre-Grad PLUS federal loan limit (Panels A and C), the introduction of Grad PLUS loans has no first-order effect on prices or enrollment. (One might expect relatively small general equilibrium effects as students move to/from other programs, however.)

In contrast, the introduction of Grad PLUS has significant first-order effects for programs with baseline prices above the previous federal loan limit. When the supply of seats is perfectly inelastic, the introduction of Grad PLUS leads to no change in enrollment and prices increase from T_0 to T_1 (Figure 1, Panel B). When supply is more elastic, both prices and enrollment increase but the change in price is smaller than in the case of programs with perfectly inelastic supply (Panel D). To the extent that Grad PLUS lowers the cost of taking on additional student loan debt, the new program can be thought of as a price subsidy for the "product" of graduate education. As is the case with standard models of tax incidence, the economic incidence of this subsidy will depend on the relative elasticities of supply and demand, with the less elastic side of the market receiving a larger share of the benefit.

This simple model generates predictions for heterogeneity in the effects of Grad PLUS on enrollment and prices. First, programs with baseline prices below the pre-Grad PLUS limit should see smaller or no changes in enrollment and prices compared to those with prices above the baseline federal limit. Second, for the latter set of programs, price responses to Grad PLUS will be larger and enrollment responses smaller where supply is less elastic. If there are demographic or other characteristics that are predictive of being constrained, enrollment responses by students in these groups should be larger than for individuals who are less likely to be constrained, and programs serving a larger share of students who are constrained should have larger price increases.

We can test these simple predictions empirically. While we do not directly observe the elasticity of supply for the individual programs, we construct two proxies for it. The first is a measure of the variation in entering cohort size in our pre-policy period; programs with greater variation in year-to-year size might be more able to respond to changes in demand by increasing the number of seats offered. The second proxy is the selectivity of the program; previous work suggests that elite schools have less elastic supply curves, at least for undergraduate programs (Blair and Smetters 2021). We measure selectivity in two ways: baseline admissions rates and whether a program is located in a flagship public, research intensive ("R1"), health-related, or other type of institution.

Price discrimination is a common feature in U.S. undergraduate higher education – schools set a list price and offer discounts via institutional grants – which is only be possible if schools had some degree of market power (Turner 2017; Fillmore 2023). If graduate programs are similarly able to engage in perfect price discrimination, changes in the list price in response to the Grad PLUS subsidy would reflect changes in the willingness to pay of the students with the highest willingness to pay. Turner (2017) shows that in the case of monopoly or monopolistic competition, the extent to which increases in grant aid for a given type of student absorbs the overall list price increase will reflect both such students' responsiveness to price changes and the extent to which enrolling more students in a given group contributes to a school's objectives (if they deviate from profit maximization). Predicting which students would receive additional institutional aid requires stronger assumptions about programs' objectives and so we do not have strong predictions; rather, we test for changes in aid across different groups to explore this empirically.

3. Data and Characteristics of Constrained Students and Programs

We use de-identified administrative data from the University of Texas at Austin's 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. The THECB data contain individual-level information on enrollment and graduation for graduate students enrolled in public and nonprofit higher education institutions but excludes the approximately 2 percent of graduate students attending for-profit institutions over this time period. 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 these data is close to ideal for studying how the Grad PLUS program affected the decisions of most graduate students and institutions.

We link student records to data from the Texas Workforce Commission (TWC) containing quarterly earnings records for all workers covered by the Texas Unemployment Insurance (UI) system. Our data starts in the 2000-2001 (hereafter, 2001) academic year, which is the first year in which financial aid information is available. The financial aid data include information on grant and loan disbursements, but we do not observe loan repayment.

We supplement these data with information on admissions rates from the 2007 and 2008 editions of the *U.S. News and World Report's Best Graduate Schools* guides (covering 2005 and 2006 applicants, respectively) for a subset of programs (business administration, law, medicine, and education) combined with pre-Grad PLUS THECB graduate admissions data for another subset of programs (pharmacy, dental, optometry, veterinary medicine) and calculate the residual admissions rate for all other graduate programs based on university-wide applications and admissions data. Appendix B contains additional details on these data sources.

3.1 Defining Graduate Programs

Conceptually, a program of study is a series of courses in the same field 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.[10] 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.

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

[10] In contrast to the more limited funding available to professional degree-seeking graduate students, students in academic PhD programs commonly receive tuition waivers and stipends. 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 (authors' calculations using the 2004 National Postsecondary Student Aid Study).

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 doctoral 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.[11] Additionally, education and engineering programs are defined at the 2-digit CIP level.[12] More details can be found in Appendix B; our results are robust to using alternative cut-offs in our classification of academic and professional programs. We observe the program of study for the vast majority of graduate students attending public institutions and for a subset of private nonprofit graduate students.[13]

3.2 Characteristics of first-time graduate students

Table 1 shows summary statistics for students entering Texas public and nonprofit graduate programs 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

[11] This is to match the treatment of these programs in other nationally representative data sets, such as the National Postsecondary Student Aid Study (NPSAS), which classifies health and education programs (including doctoral programs) as being distinct from academic PhD programs.

[12] 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.

[13] Private schools in Texas are required to submit a different information to the THECB. We can identify theology, education, law, and chiropractic programs in nonprofit institutions. Appendix B provides additional details on the subset of programs in private nonprofit institutions that are observable prior to degree completion. Using data from the NPSAS – a nationally representative sample of graduate students – Appendix Table B.1 shows that, nationwide, an estimated 72 percent of graduate students in 2004 and 67 percent in 2008 would meet the criteria for inclusion in the Texas sample (i.e., they were enrolled in a public institution or in the subset of programs that are consistently observed in Texas nonprofit institutions), suggesting our sample is representative of a large fraction of the relevant population. Nationwide, students in program-institution combinations that would be observed in the Texas data are less likely to borrow or be constrained borrowers in their first year and attend programs with lower costs of attendance (Appendix Table B.2).

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; this trend is explored in more detail in Denning and Turner (2025). The most common broad areas of study are education (24 percent, across all entering cohorts), business (15 percent), health (15 percent), and engineering (8 percent). Approximately 13 percent of graduate students entered a science, technology, engineering, or math (STEM) program of study (as defined by the U.S. Department of Homeland Security).

We next look at the distribution of entering graduate students across institutions, dividing schools into four mutually exclusive groups: health-related institutions, flagship public institutions (University of Texas at Austin and Texas A&M), non-flagship research intensive or "R1" institutions, and all other schools.[14] Around 8 percent of entering graduate students enrolled in a health-related institution, 13 percent in a flagship, 28 percent in an R1 school, and the remaining 50 percent in a non-R1 institution. The distribution of students across institution types was fairly stable in the years before and after the creation of Grad PLUS, with only small decreases in the share entering a flagship or R1 and small increases in non-R1 enrollment.

On average, 36 percent of new graduate students borrowed in their first year, growing from 32 percent before Grad PLUS to 40 percent after. Across all periods, only 2 percent of graduate students – representing 6 percent of graduate student borrowers – took out private loans in their entry year. 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 $6,300 for pre-Grad PLUS cohorts to approximately $8,300 for later

[14] Health institutions are identified based on the THECB's classification; these are primarily institutions associated with hospitals/medical systems like the Baylor College of Medicine and Texas Tech Health Science Center. R1 schools are those classified as "Doctoral Universities [with] Very high research activity" according to the Carnegie Classification. See Appendix Table B.3 for a list of the institutions in each category.

cohorts. Entering graduate students faced an average (inflation-adjusted) cost of attendance of just under $29,000 prior to Grad PLUS and just over $31,000 in later years.

First time graduate students in Texas are similar to graduate program entrants nationwide with respect to their race/ethnicity, gender, and age (Appendix Table A.1). Texas graduate entrants attend programs with a similar cost of attendance to those entering graduate programs nationwide but take on $3000 to $4000 less student loan debt in their first year.

3.3 Which programs and students were potentially constrained?

We next describe the types of programs and students most likely to be affected by the introduction of Grad PLUS, specifically programs with prices above the Stafford Loan borrowing limit and students who exhausted their Stafford Loan eligibility. Figure 2 plots program-level prices relative to the federal borrowing limit (indicated by the vertical line) in 2006.[15] Most programs had prices below the pre-Grad PLUS federal maximum. In the absence of price increases, students in these programs would not be able to borrow more when Grad PLUS was introduced. However, a substantial minority of programs had prices at least $10,000 above the prevailing federal borrowing limit in 2006. Interestingly, there is bunching just below the federal maximum as well, suggesting that the maximum a student could borrow may have affected pricing decisions in the pre-period.

Programs most likely to be affected by the introduction of Grad PLUS – those with baseline prices above the federal borrowing limit – had higher prices and per-student borrowing prior to creation of the program. Appendix Table A.2 shows the characteristics of programs with prices above and below the federal borrowing limit in the years before Grad PLUS was created. Programs with prices above the limit were disproportionately in private nonprofit institutions and less likely to be in education (8 percent versus 33 percent of programs with prices below the limit). All law programs had baseline prices above the maximum, and all psychology programs had prices below the maximum. Business, social services, and STEM programs (including or excluding medical degrees) were equally represented within the programs above and below the federal loan limit.

Motivated by our conceptual framework, we are also interested in programs that have a higher elasticity of supply. To this end, we construct a measure which we call a program's

[15] Appendix Figure A.1 shows the distribution of program-level prices in nominal terms in 2004 through 2010.

“spread” over the three academic years prior to the creation of Grad PLUS, equal to the difference between the largest entering cohort and the smallest entering cohort, divided by the average entering cohort size. Programs with baseline prices above the federal limit have less capacity to expand as measured by their “spread” and lower acceptance rates. Programs with baseline prices above the Stafford Loan limit were larger and had entering cohorts with larger shares of international students and men and smaller shares of Black and Hispanic students. Finally, students entering these programs had higher EFCs.

We follow Black et al (2023) and describe borrowers who were more and less likely to be affected by the introduction of Grad PLUS based on their borrowing behavior in their first year of enrollment. We define constrained borrowers as students who are likely to choose to borrow above the Stafford Loan limit if they had access to additional loans. Empirically, these are students borrowing at the Stafford Loan limit. Appendix Table A.3 presents summary statistics for constrained and unconstrained borrowers who entered a graduate program in the years before and after the creation of Grad PLUS. Constrained borrowers differ in their demographic characteristics – they are more likely to be white, less likely to be Hispanic and Asian/Pacific Islander, less likely to be Texas residents, and more likely to be men.

About 7 percent of borrowers entering graduate programs pre-Grad PLUS took out private loans. Constrained students were four times more likely to have private student loans (16 versus 4 percent). After the creation of Grad PLUS, use of private loans dropped with approximately 4 percent of both constrained and unconstrained borrowers. Almost a quarter of constrained students took out Grad PLUS loans in the post-period. Although we cannot say whether students were constrained in terms of their ability to access private loans, we do know that the typical graduate student who borrowed from a private lender had a higher interest rate than federal loan options. Differences in repayment options – such as the availability of income driven repayment plans for federal loans – would also contribute to private loans being significantly more expensive than federal loan options. However, private loans sometimes have the option of adding a co-signer.

Unsurprisingly, constrained students attend different programs than unconstrained students – programs that are approximately $13,000 more expensive than those attended by unconstrained students. Constrained students are more likely to be in law programs and less likely to be in programs in other fields. Constrained students also borrow more (by definition) and receive slightly higher grant aid in their first year compared to unconstrained students.

4. Effects of increased loan limits on graduate program access

The simple conceptual framework in Section 2 suggests a natural control group for examining the effect of Grad PLUS on enrollment, namely, programs with prices below the pre-Grad PLUS Stafford Loan maximum.[16] Thus, to examine the effects of higher federal loan limits on access to graduate education, we leverage variation in baseline program prices 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 graduate students attended programs with prices below the Stafford Loan limit at baseline.

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. Among programs with baseline prices above the pre-Grad PLUS limit, those with larger increases in borrowing limits should see weakly more enrollment by prospective students whose

[16] Additionally, the conceptual framework suggests that, conditional on the elasticity of supply, enrollment responses should be larger in programs where there is a larger share of "constrained" individuals in the pool of prospective students. Unfortunately, we do not have individual-level data on prospective graduate students and thus cannot construct a measure that could be used to test this dimension of heterogeneity. However, we can test the prediction that increases in enrollment should be larger for groups of students more likely to be constrained.

constraints are relaxed with the introduction of Grad PLUS (e.g., the gap between D_0 and D_1 in Figure 1 is increasing in baseline prices).

4.1 Analysis sample

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 entering cohorts in each of the 2004 through 2010 academic years and had at least 20 students per year who filed a FAFSA, on average, in 2004 through 2006.[17] 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.

4.2 Empirical strategy

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 by higher loan limits.[18] 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"). Among programs that would experience borrowing limit expansions based on pre-period prices, the average increase was just over $5,000 with a standard deviation of approximately $8,800.[19]

[17] This program-level panel begins in 2004 because data for nonprofit institutions is first available in 2003. Because we are focused on the characteristics of entering students, we need to determine whether a student has previous enrollment, which requires at least one year of prior data. Hence 2004 is the earliest year where we can determine if someone is enrolling in a program in a nonprofit institution 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, but show our results are robust to increasing or decreasing this minimum.

[18] In the following section, we 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.

[19] Appendix Table A.4 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.

This "intent-to-treat" approach has the advantage of requiring fewer assumptions, but the disadvantage of not directly relating changes in enrollment or the characteristics of entering students to actual changes in 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.

We also estimate instrumental variables models in which a program's actual loan limit is the endogenous regressor 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 higher loan limits on graduate program access.

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 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-entry cohort observations by average pre-period entry cohort size. Although this approach uses both the extensive margin of the policy change and a continuous measure of exposure to the policy change as identifying 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).[20]

[20] 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.

4.3 Main estimates

Point estimates of γ^c and corresponding 95 percent confidence intervals from equation (1) are displayed in Figure 3. Panel A shows that the predicted federal loan limit increase based on 2006 prices is quite predictive of the actual increase in borrowing limits.[21] 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 3 also shows that in the years following Grad PLUS, neither overall enrollment (Panel C) nor the demographics of entering students (Panels D E, and F) in programs with larger projected loan limit increases changed differentially relative to unaffected programs. We also note that, while we only have data from Texas, Grad PLUS was implemented nationally, so there is no reason to expect differential effects on students' decision to enroll in Texas.

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, $Post_c$:

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

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).

Columns 2 through 8 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, men, and students without a college

[21] What appears to be a significant pre-trend in the federal loan limit is due to the dependent variable's inflation adjustment (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.

educated parent ("first gen" students). 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. 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. In contrast, we find positive effects, albeit economically small, on the percent of entering students who were White or Asian/Pacific Islander (API). Specifically, a $1000 increase in projected loan limits led to a 0.08 percentage point increase in the percent of entering students who were white and a 0.02 percentage point increase in API students. These results suggest there is very little change in enrollment or cohort composition as a result of loan limit increases.

Table 2, Panel B displays estimates from IV models in which we instrument for a program's realized limit increase with the projected limit increase.[22] 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 0.5 student increases in enrollment (0.3 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 effects on the share of entering students who were Black or Hispanic larger than 0.02 and 0.06 percentage points, respectively, per $1000 increase in loan limits. Altogether, these estimates suggest that increases in borrowing limits that were caused by Grad PLUS did not expand graduate program access, on average.

4.4 Heterogeneity

Our conceptual framework predicts that programs with greater supply elasticity should see relatively larger enrollment increases when baseline prices are above the pre-Grad PLUS federal loan limit. We estimate a version of equation (2) in which all regressors are fully interacted with indicators for whether a program has above or below median capacity to expand, as measured by the program's "spread". As shown in Panel A of Table 3, across all 8 main outcomes, our only

[22] We focus on the actual limit increase rather than realized increases in borrowing as the first stage for our IV model because the *option* to borrow more from the federal government could affect enrollment decisions even if students do not take advantage of the additional loan aid. In Sections 5 and 6, we directly test for effects of higher loan limits for constrained borrowers – those who have exhausted their Stafford Loan eligibility. That said, Appendix Table A.5 provides OLS and IV estimates of the effect of the projected and actual limit increases on borrowing outcomes, including the share of entering students with Grad PLUS loans, any federal loans, and loans from any sources and the average amount borrowed in each of these categories.

evidence of heterogeneity at conventional levels of statistical significance ($p < 0.1$) is in the case of the overall number of students enrolled, and differences in enrollment for programs with low and high capacity to expand at baseline are small (-2.3 versus 1 additional student per $1000 predicted increase in loan limits). This is notable because the larger increase in enrollment for the latter group is consistent with predictions from our conceptual model but only represents a 1 percent gain over baseline enrollment for such programs (110 students).

When we test for heterogeneity by program selectivity, we find little evidence of heterogeneous effects of higher loan limits that is of an economically meaningful magnitude (Table 3, Panel B). Again, we find statistically significant ($p < 0.05$) heterogeneity for only one out of the 8 outcomes, with less selective programs seeing a 0.6 percentage point increase in the share of the entering cohort that are international students (a group that cannot access federal student loans).

Finally, we examine whether the effects of higher loan limits have heterogeneous effects on enrollment and access across different types of institutions. As can be seen in Panel C of Table 3, although there is some evidence of significant heterogeneity in treatment effects across different types of institutions for the share of entering students who are Black ($p < 0.05$), Hispanic ($p < 0.01$), and API ($p < 0.01$), we again find no evidence of economically meaningful changes in enrollment or cohort composition for any category of institution.[23]

4.5 Robustness

Our estimates are robust to a variety of alternative specifications and sample definitions (Appendix Table A.6). We start by testing whether our results are robust to different ways of constructing the predicted limit increase. Results in Panel A come from models that use an alternative measure of a program's cost of attendance – the average COA from 2004 through 2006 (versus 2006 in our main specification). This has the advantage of more data being used to calculate the cost of attendance; however, given trends in tuition, earlier years may be less predictive of future prices than 2006 alone. Next, we take into account grant aid received by students at baseline when calculating the projected limit increase as students cannot borrow more than the cost of attendance less grant aid (Panel B). Third, we use the predicted program price for

[23] In related work, Denning and Turner (2023) show that access to programs that typically lead to high earnings was not affected by expansions in loan limits due to Grad PLUS.

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. Estimates are similar to our main results in all cases.

Next, we test for robustness to altering the construction of the analysis sample. We expand the years used in estimation to go until 2013 to test for effects on access over a longer time horizon (Panel D). 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 E). This allows us to use smaller programs but also makes our average cost of attendance more sensitive to outliers. We show our estimates are robust to including HBCU programs in the analysis sample (Panel F). We find similar results when we exclude academic doctoral programs from the analysis sample (Panel G) or programs with either all or no observations with prices above the Stafford Loan limit at baseline (JD and clinical psychology programs, respectively, shown in Panel H). Appendix Table B.4 shows that our estimates are robust to using different thresholds of terminal master's degrees granted to define academic programs. Finally, we exclude programs with prices "bunching" just below the Stafford Loan limit at baseline (e.g., Figure 2); results are shown in Panel I. In all cases, our estimates are very similar to those produced by our main specification.

In our third set of robustness tests, we show that our estimates are robust to choice of specification. We estimate models that do not weight observations by baseline program size (Panel J). 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 K). We also estimate models that include a piecewise linear spline in the projected limit increase to test whether increases in loan limits have differential effects at higher potential levels of borrowing. Specifically, we interact the projected limit increase with indicators for above and below the median projected limit increase (approximately $5200) among programs with a nonzero projected limit increase (weighted by pre-period number of students). As shown in Panel L, we find some limited evidence of significant increases in the share of entering students without a college educated parent due to higher loan limits for programs with lower baseline prices. Finally, we allow for a separate treatment effect of Grad

PLUS for programs with prices just below the baseline limit ("bunchers") as at least some of these programs likely would have optimally charged above this amount had federal limits been higher. As can be seen in Panel M, we do not find evidence of increased enrollment or access due to Grad PLUS for such programs nor does excluding them from the control group affect our estimates of enrollment responses to higher loan limits.

4.6 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 first provide descriptive evidence on the frequency and characteristics of programs that were created in the years before and after Grad PLUS. In the four academic years before Grad PLUS, 26 new programs were created per year, on average and the average size of entering cohorts for a new program was 15. In four years following the creation of Grad PLUS, an average of 31 new programs were created per year with average cohort size of 21. After Grad PLUS, newly created programs were more likely to be education and psychology and less likely to be in computer and information sciences and health fields (Appendix Figure A.2). Appendix Table A.7 shows that post Grad PLUS, new programs had larger shares of entering students who were Black (15 vs. 7 percent), Hispanic (28 vs. 15 percent), and first generation (57 vs. 36 percent). Although new programs in the post-Grad PLUS period were relatively lower in the overall distribution of program prices (among new and existing programs), within the schools in which they were located, they had relatively higher prices. Finally, non-R1 institutions were more likely to create new programs after Grad PLUS than in earlier years (78 vs. 42 percent).

Second, 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.8 contains these estimates, which are quite similar to the program level estimates shown in Table 2. Taken together, these two sets of results suggest that the creation of new graduate programs had negligible effects on overall enrollment or student composition.

Our results speak to an often-referenced potential benefit of Grad PLUS—increasing access to graduate education. We find no such benefit overall. Similarly, we find no effect on the composition of entering graduate students, suggesting that binding credit constraints were not the determinative factor for prospective students' ability to enroll in graduate school prior to the advent of Grad PLUS, even among those who are traditionally underrepresented in graduate school.

5. Effects on program prices

Although graduate students were the statutory beneficiaries of increased access to federal loans after the Grad PLUS program was created, some of the benefits of the program may have been passed through to programs and institutions in the form of higher prices. Further, our conceptual framework suggests that increases in prices should be higher for programs serving a larger share of students constrained by pre-Grad PLUS federal loan limits and those with less elastic supply. Thus, in this section, we turn to examine the effects of the increase in federal loan availability and borrowing on graduate program prices.

5.1 Analysis sample

We construct a program-by-year level data that is based on all students enrolled in the program in an academic year. 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). Thus, we calculate the average cost of attendance (COA) for each program among enrolled students who submitted a federal student aid application.

The tuition component of a program's COA 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 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. Thus, we use a second measure of price – the predicted COA for a full-time, full-year (FTFY) student.

Specifically, we regress a student's COA on credits attempted in each semester, semesters of enrolled, and fixed effects for program and academic year, limiting the sample to students who enrolled before Grad PLUS. We use these estimates to predict the FTFY cost of attendance for each program. To the extent that non-tuition elements of COA are the same within a given institution, in a given year, this method will account for those differences.

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 number of students submitting financial aid information in a given year in the pre-period is at least 20 to avoid relying on identifying variation from small programs, which will be measured with more noise. We later show the results are robust to relaxing these enrollment-based sample restrictions.

5.2 Empirical strategy

Ideally, to determine the pass-through of federal loan generosity from students to institutions, we would compare increases in prices to increases in borrowing. 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 ("constrained students") before the Grad PLUS program to changes in prices for graduate programs where few students were constrained by the statutory limit in earlier years.[24] 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.[25] Our estimating equation is:

$$Y_{pc} = \beta\left(Pct_{p,pre} * Post_c\right) + \theta_c + \theta_p + \varepsilon_{pc} \qquad (3)$$

[24] 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. In their proposition A3, they show that more constrained students lead to larger changes in prices in response to increases in loan limits. This strategy allows two programs that both have the same price to have different reactions to Grad PLUS depending on how much one program's students exhaust their loan eligibility.

[25] The conceptual framework in Section 2 also suggests that programs with baseline prices below the limit will be less responsive than programs with prices above the limit. We incorporate this variation in one of our robustness tests and find similar results with a weaker "first stage" effect on borrowing.

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 all enrolled 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). 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. We define the percent constrained as the share of all enrolled students (including nonborrowers) who have federal student loans 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.

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 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. Additionally, the non-tuition components should largely be fixed across program within a given institution, so program fixed effects should account for university-level changes.

On average, prior to Grad PLUS, 15 percent of students were constrained borrowers, 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. The median program had 5.6 percent of students constrained at baseline.[26]

5.3 Main estimates

Figure 4 shows estimates and 95 percent confidence intervals from event study models in which $Post_c$ in equation (3) 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

[26] Appendix Table A.9 shows the (enrollment weighted) characteristics of programs by quartile of percent constrained. Appendix Table A.10 provides average characteristics of programs in the main analysis sample in the academic years before and after Grad PLUS.

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 prices. Estimated effects are of a similar magnitude to the estimated effects on average Grad PLUS loans received by students in a program.[27]

Table 4 presents estimates from equation (3) of the effect of Grad PLUS exposure 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 $88 increase in per student Grad PLUS borrowing, on average. In total, annual federal loan aid per student increased by $60.[28] Some of the increase in federal borrowing was offset by a statistically significant $37 decrease in average private student loans per student, while state loan aid was unaffected.

Estimated effects on prices from equation (5) are shown in Panel A of Table 5. 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 $66 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 4, these estimates suggest that prices increased by approximately $0.75 per $1 increase in average per-student Grad PLUS loans and more than dollar for dollar with increases in 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. A little over one third of the increase in cost of

[27] In theory, average Grad PLUS loans per student should be $0 in the pre-period. However, the THECB reported PLUS and SLS loans in the same field and a very small number of students had nonzero SLS loans in the pre-period.

[28] 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 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 or a change in the distribution of amounts borrowed with increases in the probability of both small and large loans.

attendance was offset by a $26 increase in institutional grants per 1 percentage point increase in share constrained (Table 5, 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 per student federal loan aid is the endogenous regressor and $Pct_{p,pre} * Post_c$ serves as the excluded instrument; estimates are shown in Panel B of Table 5.[29] 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 resulted in a significant $1.10 increase in a program's list price and a $0.64 increase in net price.

5.4 Heterogeneity

To better understand which programs and institutions are driving the changes in prices, we explore heterogeneity based on the elasticity of supply of the program—again, this includes the spread of the enrollment in the pre-period, the admissions rate in the pre-period, and the type of institution. Similar to our approach to testing for heterogeneous effects of Grad PLUS on enrollment, we estimate versions of equation (3) that fully interact mutually exclusive categories of programs or institutions with all independent variables.

Panel A of Table 6 presents estimates from models that test for heterogeneity in our proxy for a program's capacity to expand. We find evidence of significant and economically meaningful heterogeneity. Programs with lower capacity to expand saw significantly larger increases in borrowing and prices than programs with greater capacity to expand. The change in net price was also larger, though this is not statistically different from the net price effects for programs with greater capacity to expand.

Next, we test for heterogeneity by program selectivity by dividing programs into those with above and below median baseline admissions rates (Table 6, Panel B). We cannot reject a test of the hypothesis that total federal borrowing or prices respond differently to exposure to Grad

[29] 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 – the terms and availability of both Stafford and PLUS Loans are determined by the federal government, whereas private loans may adjust endogenously to these policy decisions.

PLUS in less versus more selective programs.[30] That said, effects on prices are larger for programs with lower admissions rates and close to significantly different at conventional levels in the case of net price ($p = 0.105$).

Finally, we test for differences in borrowing and pricing responses to Grad PLUS across different types of institutions (Table 6, Panel C). Across all institution types, increased exposure to Grad PLUS results in increases in Grad PLUS loans, with the largest responses by programs in flagship and R1 institutions, followed by non-R1 institutions ($p < 0.001$). There are also significant differences in federal per-student borrowing responses to Grad PLUS exposure ($p < 0.001$), with borrowing among students attending programs in flagship and R1 institutions increasing by \$128 and \$89 per 1 percentage point increase in exposure and small, statistically insignificant changes by students in programs located in health-related and other institutions. Increased exposure to Grad PLUS results in significant increases in cost of attendance for programs not located in health-related institutions, with the largest increases again occurring within flagship schools. Net price increases are largest for programs in flagship institutions. We can reject tests of the hypotheses that treatment effects on cost of attendance and treatment effects on net price are the same at the 5 and 10 percent levels, respectively. Pass-through of increased federal loans is largest for programs in flagship institutions (\$0.90 increase in net price per \$1 increase in loans compared to approximately \$0.78 per \$1 increase in R1 and other institutions). A limitation of our data is that we do not observe for-profit institutions and only observe a subset of programs in private nonprofit institutions. Given prior research on pricing responses to changes in federal student aid generosity for undergraduates find larger effects for nonprofits and/or for-profit institutions (Turner 2017; Lucca et al. 2019), our estimates of pricing responses to Grad PLUS-driven borrowing increases may represent a lower bound.

Taken together, these results provide suggestive evidence of larger price responses to Grad PLUS in more selective programs and those with less elastic supply, as predicted by our conceptual framework. The welfare consequences of such responses will depend on how the

[30] We find significantly larger treatment effects on Grad PLUS loans (\$154 increase per 1 percentage point increase in baseline percent constrained for more selective programs versus \$9 for less selective programs, $p < 0.001$) and effects on total federal borrowing that are smaller (\$130 increase per 1 percentage point increase in baseline percent constrained for more selective programs versus \$215 for less selective programs). This pattern could be explained by constrained students in less selective programs taking advantage of the \$2000 increase in Stafford Loan limits but not needing to rely on Grad PLUS loans and/or differential changes in the composition of who borrows with fewer students borrowing larger amounts in more selective institutions).

additional revenue is spent. Although information on expenditures is generally not available at the sub-institution level, we do observe one potential source of spending: institutional grant aid.

5.5 Price Discrimination

As discussed in our conceptual framework, while 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. We do not have predictions from our conceptual framework about which students will see the biggest changes in net price; thus, we investigate empirically the extent to which Grad PLUS-induced price increases affected the distribution of grants to students in different groups. To do so, 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. We continue to define exposure in terms of the percentage of all students in the program who were constrained at baseline.

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 7 presents estimates by student race/ethnicity. We find some evidence of heterogeneous borrowing responses to greater exposure to Grad PLUS: Black students' federal loans increased by $89 per 1 percentage point increase in baseline percent constrained, Hispanic and white students' loans increased by $54, and Asian and Pacific Islander (API) students saw a $46 increase in average Grad PLUS loans. In contrast, we find the largest increase in average grant aid among white students, $37 per 1 percentage point increase in baseline percent constrained. Average grant aid increased by $30 for Hispanic and API students and $17 for Black students. These differences in grant aid translate into differences in net price. On average, Black students saw their net price increase by $40 per 1 percentage point increase in baseline exposure and Hispanic students saw a $17 increase. Increases in average net prices faced by white and API students were $8 and $9, 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 aid, and price effects by measures of socioeconomic status (SES); Table 8 contains these results. Students with below median financial need (EFC) have the largest increases in borrowing ($90 per 1 percentage point increase in Grad PLUS exposure) and students who received a Pell Grant as an undergraduate in Texas see the smallest increases in grant aid ($21) but overall, differences in borrowing and grant aid receipt are much smaller across these groups compared to the differences by race/ethnicity.

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 9 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. Differences in estimated effects by Pell Grant receipt, parental education, and EFC are not statistically different.

Overall, these results demonstrate the burden of higher prices due to Grad PLUS-driven borrowing increases was not born disproportionately by higher-SES students as the benefits of increased grant aid were not targeted to students in groups that have been historically underrepresented in graduate school. Although 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.

5.6 Robustness

We test the robustness of these results to the sample selection criteria, the measurement of exposure to Grad PLUS, and functional form. Changing the minimum program size required for sample inclusion from 20 to 10 or 30 produces very similar results (Appendix Table A.11, Panels A and B). We obtain similar estimates when academic doctoral programs are excluded (Panel C). In Panel D, we test for robustness to excluding programs in fields where either all or none of the programs had baseline prices above the Stafford Loan limit (law and psychology, respectively).

We obtain similar, albeit less precise, effects on cost of attendance, but effects on grant aid are less robust. Because the criteria for institutions to include students in the reporting of financial aid and cost data changed over the academic years we examine, we test for robustness to imposing a consistent definition and find similar effects to our main results (Panel E).

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 F). 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 G), total borrowing at the Stafford maximum not accounting for partial year enrollment (Panel H), and federal borrowing at the Stafford maximum accounting for partial year enrollment (Panel I). 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 (Panel G). The implied increase in cost of attendance per \$1 increase in per-student federal loans (\$0.85) is relatively similar to our main estimates (\$1.10) but the implied effect on net price is smaller (\$0.31 per \$1 increase in federal loans versus our main estimate of \$0.64). We also estimate a model with separate indicators for programs in the middle and top terciles of baseline percent constrained (with the bottom tercile serving as the excluded category). Panel K shows that, as expected, effects on federal borrowing and prices are driven by programs in the top tercile (i.e. the most constrained, with baseline constrained above 13 percent). Results in Panel L 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.5). Finally, we use a simulated instrument approach in which we also take into account the projected limit increase when estimating treatment effects (i.e., we replace $\left(Pct_{p,pre} * Post_c\right)$ with $\left(Pct_{p,pre} * Post_c * LimInc_p\right)$ in equation (3)). 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.

6. Effects on student academic and labor market success

In our final set of analyses, we examine the effect of increased access 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, it may be that students who have already made the decision to enroll in the absence of Grad PLUS are able to persist and are more likely to graduate and receive higher earnings with expanded access to credit, as was the case for constrained undergraduate borrowers who gained access to higher loan limits in Black et al. (2023). We test these predictions in our setting by comparing changes in the outcomes of individuals who are likely to be constrained without Grad PLUS to those who are likely unconstrained.

6.1 Analysis sample

We construct a student-level panel data set to study how the loan expansion affected the outcomes of enrolled graduate students. We restrict the sample to enrolled students who borrowed through any loan program in their first year to enable comparisons between similar students who had demonstrated a need to borrow, categorizing 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.

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 Grad PLUS. 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. Furthermore, in Section 4, we show that programs in which students would have experienced relatively larger increases in loan limits saw no changes in enrollment or observable student characteristics after Grad PLUS. Under the assumption of no differential changes in the unobservable characteristics of constrained and unconstrained borrowers, we proceed by including both students who were enrolled when Grad PLUS was created and those who entered after Grad PLUS in our main analysis sample.

6.2 Empirical strategy

Our identification strategy follows Black et al. (2023) and compares the outcomes of constrained and unconstrained students who entered in cohorts that were more and less affected by the Grad PLUS increase in borrowing limits. We estimate:

$$Y_{ipc} = \beta(Cons_i * Post_c) + \mathbf{X_i \beta_x} + \theta_c + \theta_p + \varepsilon_{ipc} \qquad (4)$$

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 a main effect for constrained status), θ_c and θ_p are entry cohort and entry program fixed effects, respectively. Standard errors are clustered at the entry program level.

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. We provide evidence in support of this fundamentally untestable assumption 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.

A second complication involves identifying *which* entry cohorts were treated. 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 (4) except $Post_c$ is replaced with a set of entry cohort indicators—in which the dependent variable is cumulative Grad PLUS loans:

$$Y_{ipc} = \sum_{c \neq \underline{c}} \beta^c (Cons_i * \mathbf{1}[Cohort = c]) + \mathbf{X_i \beta_x} + \theta_c + \theta_p + \varepsilon_{ipc} \qquad (5)$$

To determine the last control cohort (which will also serve as the omitted category, $\underline{c}$, we estimate equation (5) 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 5 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.[31]

To verify that the composition of constrained and unconstrained students is not changing between treatment and control cohorts, we test for differential changes in students' baseline 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.15. We find small, statistically insignificant differences in all baseline

[31] Appendix Table A.14 displays average characteristics of "constrained" and "unconstrained" graduate student borrowers in treatment and control entry cohorts.

characteristics except for EFC, for which effects are negative. Reassuringly, we find no evidence of significant changes in the predicted graduation rate.

6.3 Main estimates

Figure 6 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 (4) and separate out total loans into Grad PLUS, total federal loans (PLUS and Stafford), private loans, and state loans; results are shown in Table 10. 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 $6,410 in Grad PLUS loans (Panel A) and while cumulative federal loans increased by $6,877 (Panel B). However, about 40 percent of the increase in federal borrowing was offset by an almost $3,000 reduction in private loans (Panel C). State loans make up a very small share of loan aid received by graduate students in our sample and there is no offsetting effect on cumulative state loans (Panel D). Taken together, constrained students who gained access to Grad PLUS experienced significant increases in cumulative total student loans by just over $4,000, representing a 5 percent increase relative to average cumulative debt for constrained students in pre-Grad PLUS entry cohorts. The increase in the amount borrowed is over double the increase in cumulative debt found by Black et al. (2023) in dollar terms and only slightly smaller in percentage terms.

The last two panels of Table 10 examine effects on the extensive margin of borrowing. In their first three years of enrollment, constrained students were 11 to 13 percentage points more likely to use Grad PLUS loans and 20 percentage points more likely to have taken out Grad PLUS loans in any year of enrollment. Because students must exhaust their Stafford Loan eligibility before taking out Grad PLUS, this provides indirect evidence on the extent to which borrowing above the prior limit increased with the creation of the Grad PLUS program.

We formally test for effects of access to Grad PLUS on the distribution of constrained students' debt by estimating effects on the probability of cumulative borrowing (measured 6 years after entry) exceeding different amounts. Appendix Figure A.3 plots point estimates and 95 percent confidence intervals. Consistent with students having existing access to at least $18,500 (in nominal terms) from the Stafford Loan Program and a typical program length of 2 years, we find no evidence of increases in the probability of borrowing at least $10,000 or at least $20,000 after Grad PLUS was created. Positive effects begin at the probability of cumulative borrowing of at least $30,000, and the estimated effects are largest on the probability of borrowing at or above $100,000. Only 22 percent of constrained borrowers in cohorts that entered prior to Grad PLUS borrowed at least $100,000, so the 4.3 percentage point increase in the probability of having at least $100,000 in cumulative debt represents an almost 20 percent increase over baseline.

Thus, Grad PLUS appears to have increased total borrowing, especially the probability of taking on high amounts of student loan debt, while also shifting some existing borrowing from private to federal loans. The latter result is consistent with 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 11, 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. This is not a large increase, but a small increase in average credits attempted could translate into additional earnings depending on the returns to additional graduate course taking. Finally, we find no evidence of significant increases in graduate degree receipt (Panel Table 11, Panel C and Figure 7). 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 84 percent. Although past research shows there is substantial variation in the returns to attending different graduate programs (e.g., Altonji, Arcidiacono, Maurel 2016; Altonji and Zhong 2021; Altonji, Humphries, Zhong 2022), we find no evidence of significant effects on the probability of earning specific degrees (Appendix Tables A.16 through A.18). Nor do we find that access to Grad PLUS reduced time-to-degree among completers (Appendix Table A.19). So, although 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. As shown in Panel D of Table 11, 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. Recent work has shown that in most cases, degrees are completed within three years of entry and so years four to represent post graduate school earnings in most cases and six to ten in virtually all cases (Denning and Turner 2025). Estimated effects on the probability of having earnings continue to be positive, albeit insignificant, in the seventh through tenth years after entry. To the extent that Grad PLUS had differential effects on the probability of working in Texas for constrained versus unconstrained students in the years shortly following exit from graduate school, these results complicate the interpretation of earnings results. 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 significant effects on long-run earnings (Figure 8). Panel E of Table 11 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. 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 (albeit statistically insignificant) 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 (e.g., U.S. Department of Labor 2017), which suggests substantial mobility out of the state (even if the rate of out-migration is not correlated with treatment).

6.4 Consumption smoothing benefits

Despite our finding that access to additional loans through Grad PLUS did not lead to significant gains in attainment, constrained students still may have benefited if access to additional loan aid allowed them to smooth consumption over time. Specifically, to the extent that students expected to see an increase in earnings due to a graduate degree, Grad PLUS may have enabled them to move some of these gains into their schooling years. Notably, linking a borrowing constraint to tuition has been shown to not distort schooling behavior but can distort consumption profiles (Lochner and Monge-Naranjo 2011).[32]

To test this hypothesis, we look at two measures of available resources while in school: (1) cumulative financial aid (grants and loans) less cumulative cost of attendance and (2) the sum of cumulative financial aid and cumulative earnings less cumulative cost of attendance, both measured in the years when a student is enrolled. Measure (2) is a more complete representation of a student's available resources, but we only observe earnings on a quarterly basis, meaning we cannot fully separate out earnings received before the first and after the last semester of enrollment.

As shown in the first two columns of Appendix Table A.20, constrained students who gained access to higher loan limits through Grad PLUS saw a \$700 increase in available resources using measure (1) and a \$2100 increase in available resources using measure (2) over all of their years of enrollment (2 years or less for most students). Compared to the increase in cumulative student loans (\$4017), these estimates suggest between 45 and 80 percent of the increased borrowing was used to cover the higher cost of attendance after Grad PLUS.

6.5 Heterogeneity

The overall null effects of access to Grad PLUS on attainment and earnings could mask heterogenous effects of across students in different demographic groups, programs, or institutions. We first provide descriptive evidence on the extent to which different demographic groups potentially were constrained. Appendix Figure A.4 plots empirical cumulative distribution functions of the amount borrowed by graduate students who first enrolled after the creation of Grad PLUS. These groups include: first generation students versus students with more educated parents, in-state vs out-of-state residents, those above versus below median EFC, males versus females, and by race. The two black vertical lines represent the pre-Grad PLUS Stafford loan limit (\$18,500) and the post-Grad PLUS Stafford loan limit (\$20,500). The spike at \$8,500 is the maximum for subsidized loans. The groups with the largest share of borrowers with loan amounts above the Stafford maximum include out-of-state students, API and White

[32] Without loan forgiveness, the student's cost of this consumption smoothing would be interest payments on their student loans in excess of the market rate. (To the extent that some students could expect forgiveness, additional federal loans would also reflect a pure transfer from the government to the student.)

students, and students with higher need (as measured by above median EFC). Perhaps surprisingly, the patterns indicate that the more disadvantaged groups are the least likely to have taken out loans in excess of the Stafford limit, suggesting that these borrowers are less likely to be constrained, although these differences could also be explained by differences in the distribution of students across programs that vary in prices.

We test for heterogeneity by estimating equation (4) for different student subgroups. As shown in Appendix Table A.21, we find larger increases in borrowing for non-URM students (relative to URM students), men relative to women, students with college educated parents relative to first generation students, and out-of-state students relative to Texas residents. We find statistically significant increases in degree receipt for URM, out-of-state students, students with college educated parents, and men (although the latter two estimates are significant at the 10 percent level). Additionally, we find some evidence of an increased probability of observing earnings for URM, female, and out-of-state students which complicates interpretation of the effects on log earnings for these groups. However, we generally do not find statistically significant increases in earnings for groups without significant selection into the labor market. In general, we tend to find larger point estimates of the effect on graduation for groups that borrowed more initially, though this pattern does not universally hold.

Heterogeneous effects of higher loan limits across student demographic groups likely in part reflect differences in which programs students were enrolled in. Thus, we next test for heterogeneity across groupings of programs– STEM and medical degree programs, education, JD, business, and all other nonacademic programs (Appendix Table A.22, Panels A through E). Across all program types, constrained students in treated cohorts borrow more through the Grad PLUS program, although the increase is quite small ($200) for constrained students in education programs. In the case of students entering STEM and medicine programs, all of the increase in federal borrowing after the creation of Grad PLUS is offset by a reduction in private student loans. Private lenders may have been more willing to extend access to credit to students entering such programs due to their selectivity and higher typical post-completion earnings. Constrained JD students see the largest increases in cumulative student loan debt by far – over $17,000, a 20 percent increase from the baseline constrained student mean. Estimated effects on degree receipt are positive but relatively small for all groups except students entering education programs without any large differences.

We also test for heterogeneity based on the median time-to-degree for students who first enrolled in untreated cohorts as a proxy for program length (Appendix Table A.22, Panels F and G). We estimate separate effects for programs in which the typical student in untreated cohorts spent 2 years or less and those in which the typical student spent more than 2 years. Surprisingly, constrained students entering programs that are typically shorter increased Grad PLUS borrowing by relatively more than their counterparts entering longer programs, but the overall increase in the cumulative debt from all sources is similar for the two groups. We do not find evidence of significant heterogeneity in effects on degree completion.

Finally, we test for heterogeneity by type of institution; estimates are shown in Appendix Table A.23. We find larger effects on cumulative borrowing for students entering programs in the two flagship public institutions, but no evidence of substantial heterogeneity in attainment effects.

6.6 Robustness

Grad PLUS was created only a few years before the start of the Great Recession. Although we limit our sample to students who first enrolled before the start of the Great Recession (fall 2007 or earlier), constrained students in some of the later entry cohorts may have still been enrolled during the economic downturn and could have been differentially affected by the recession. Thus, we test for heterogeneous effects by the local intensity of the Great Recession. We follow Yagan (2019) and Black et al. (2023) and calculate the change in the average employment rate between 2007 and 2009 (as a measure of the intensity of the Great Recession) in the county where the graduate program that a student first enrolled in was located. We fully interact the change in the unemployment rate with our indicator for being constrained and in a treated cohort and other independent variables in equation (4).

Students who entered graduate programs in counties that experienced a larger change in the unemployment rate saw larger increases in borrowing (Appendix Table A.24). This is consistent with students in harder hit areas using more debt to smooth their consumption and make up for lost income associated with the recession. Despite the differences in borrowing, we do not find effect on graduate degree completion or earnings, overall or for students in counties that were more affected by the Great Recession. In summary, our null finding on graduation and earnings does not seem to be driven by places more and less affected by the Great Recession. Of course, we cannot rule out a change in unobservable characteristics for constrained versus unconstrained borrowers.

We also test for robustness to excluding entry cohorts that potentially were partially treated – specifically those comprised of students who first enrolled in 2004 or 2005. Effects on borrowing and attainment are slightly larger in magnitude but relatively similar (Appendix Table A.25).

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 Grad PLUS Program. Grad PLUS increased graduate student loans and shifted a portion of graduate borrowing from private to federal sources. In Texas, total student loan disbursements going to graduate students in public and private nonprofit institutions increased by $360 million (in inflation-adjusted terms) between 2004 and 2013, rising from $1.02 to $1.38 billion. Grad PLUS loans accounted for just under 40 percent of the increase.

However, the increase in federal loan limits did not increase access to graduate programs overall or for underrepresented students. Similarly, 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 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 before the program was created. 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. 2023). One potential explanation is that undergraduates face relatively low federal borrowing limits and may have more limited access to private student loans.

We find some evidence that Grad PLUS may have facilitated a small amount of consumption smoothing, increasing spending in the near-term potentially at the expense of higher loan payments in the longer-run. We estimate annual loan payments after making several simplifying assumptions about interest rates for private and state student loans, consolidation of federal loans, and choice of repayment plan (additional details can be found in Appendix B). Our results suggest that constrained students would pay an additional $1070 per year on a mortgage-style

10-year repayment plan due to their increased borrowing following the creation of Grad PLUS (Appendix Table A.20). Given that we do not find evidence that Grad PLUS led to significant increases in constrained students' earnings, this suggests that earnings net of student loan payments will be lower, at least for borrowers who do not anticipate receiving forgiveness through an income-driven repayment plan. However, the individual and social welfare consequences of increased borrowing due to Grad PLUS will depend on how borrowers repay their loans, which involves a complex sequence of decisions about repayment plan (and potentially job choice) and, for those that chose an income-driven repayment plan, earnings and family formation trajectories for up to 25 years after repayment entry. Estimates from the Congressional Budget Office (2024) suggested that, in present discounted value terms, the federal government will lose \$0.34 to \$0.40 of every dollar lent through the Grad PLUS program in 2024, between \$3.5 and \$4.4 billion.

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 increase 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, while only some graduate students borrow, the price increases we find were also borne by nonborrowers. Additionally, these estimates capture relatively short-run effects of Grad PLUS over the three to four years following the program's introduction; longer-term effects may differ if prospective graduate students and/or programs are more responsive to the increase in credit access.

Our results suggest that Grad PLUS loans primarily benefited institutions and programs that were able to charge higher prices. We do not have direct evidence on how all the additional revenue was spent, but we can say that some of it was directed towards increasing institutional grants. The remaining revenue may have been invested in hiring additional faculty or support staff, which could provide benefits that take a while to appear or that are not limited to constrained graduate students. Alternatively, the additional money may have been used to increase spending in other parts of the university, such as undergraduate financial aid. We leave the question of how universities spend additional revenue gained from graduate programs to future research.

Grad PLUS 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 more 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. In fact, the Grad PLUS loan program was eliminated as part of the One Big Beautiful Bill Act in 2025 with policymakers citing the possibility of price increases as motivation for this change (Goldman, 2025). Future research examining the consequences of this decrease in credit access will likely yield additional insights into the effects of student loans in graduate school.

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Figures and Tables

Figure 1: Conceptual Framework

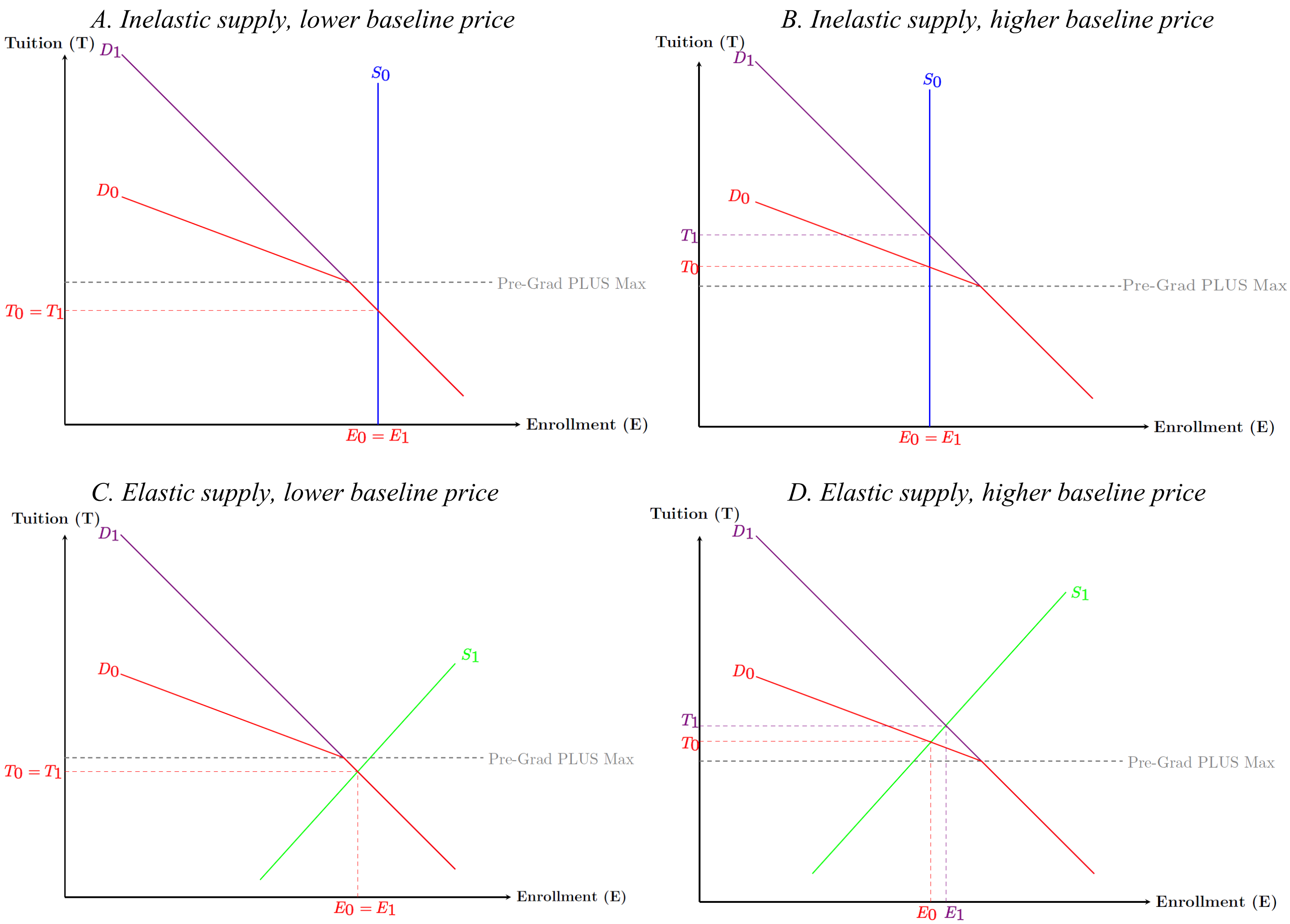
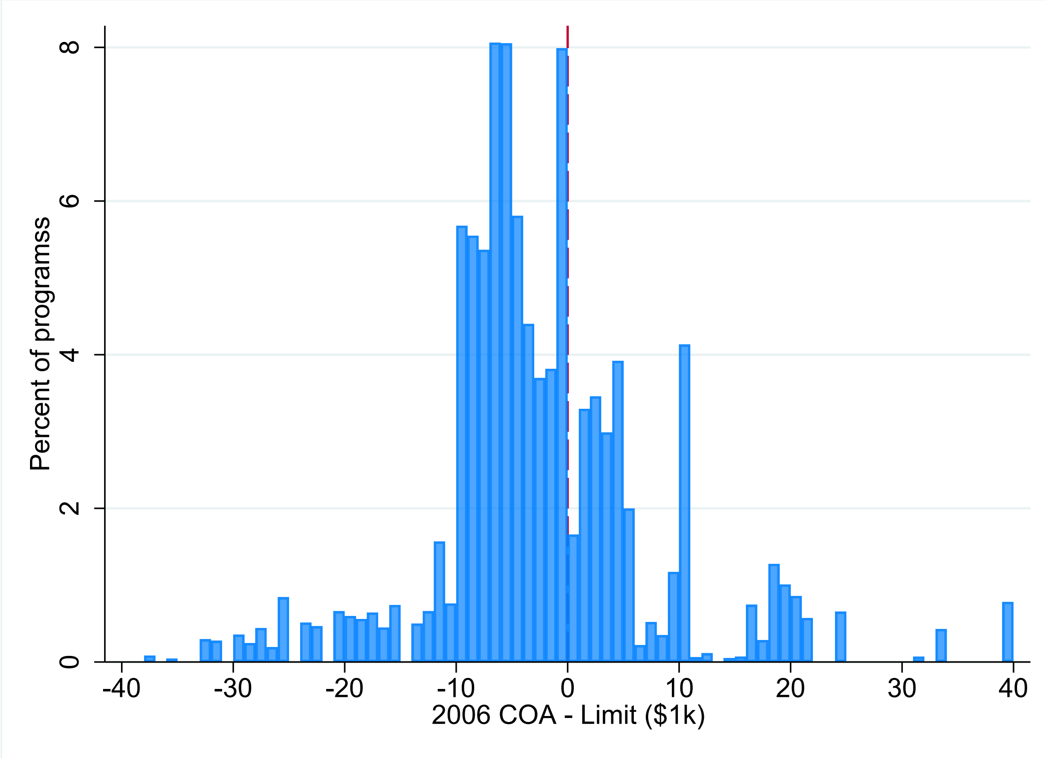


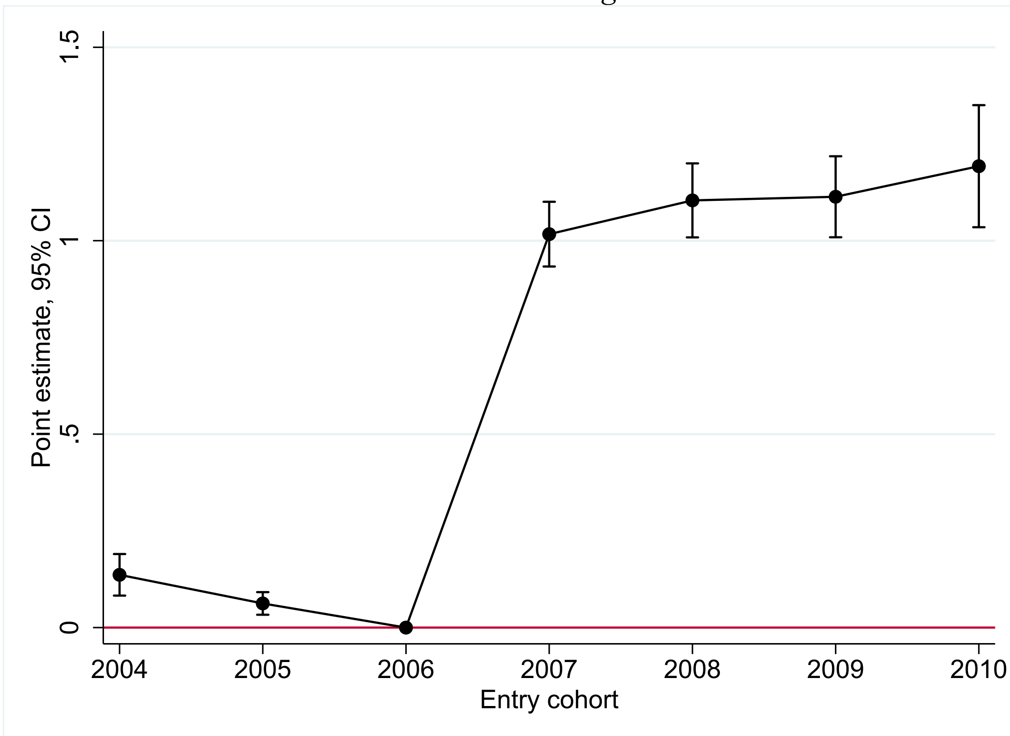
Figure 2: Distribution of 2006 Program Prices Relative to Federal Borrowing Limit



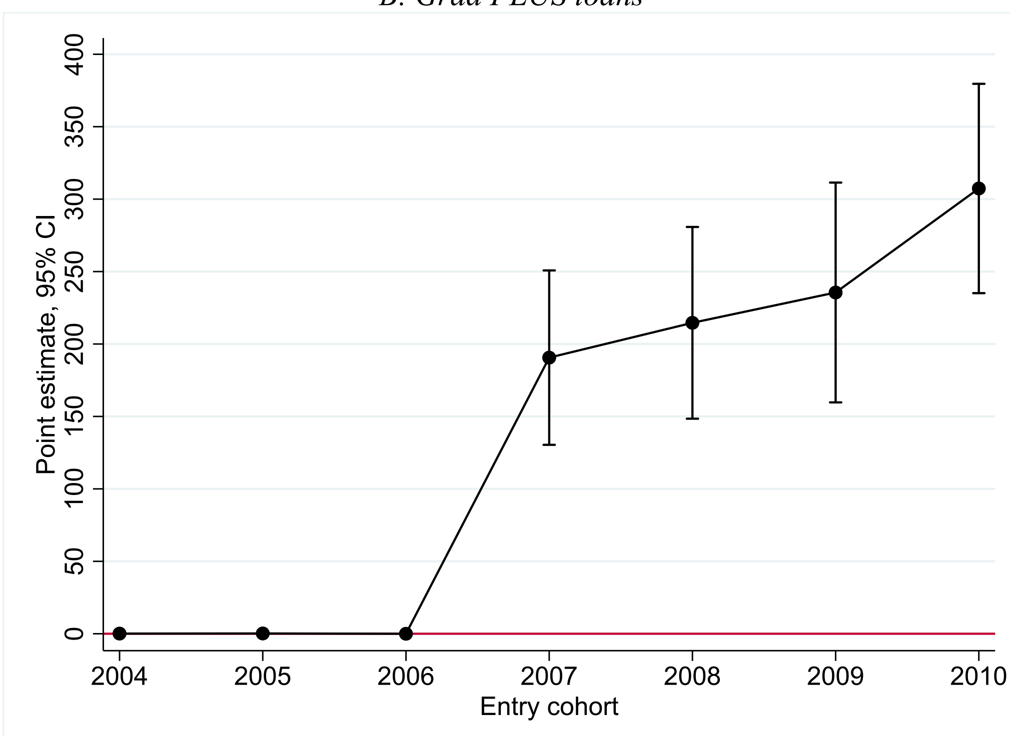
Notes: This histogram shows the (entry cohort size weighted) distribution of program prices relative to the 2006 Stafford Loan limit. The sample includes graduate programs that had entering students in each of the 2004 through 2010 academic years and had at least 20 entering students who filed a FAFSA in 2004 through 2006.

Figure 3: Effect of a $1000 increase in loan limits on graduate program access

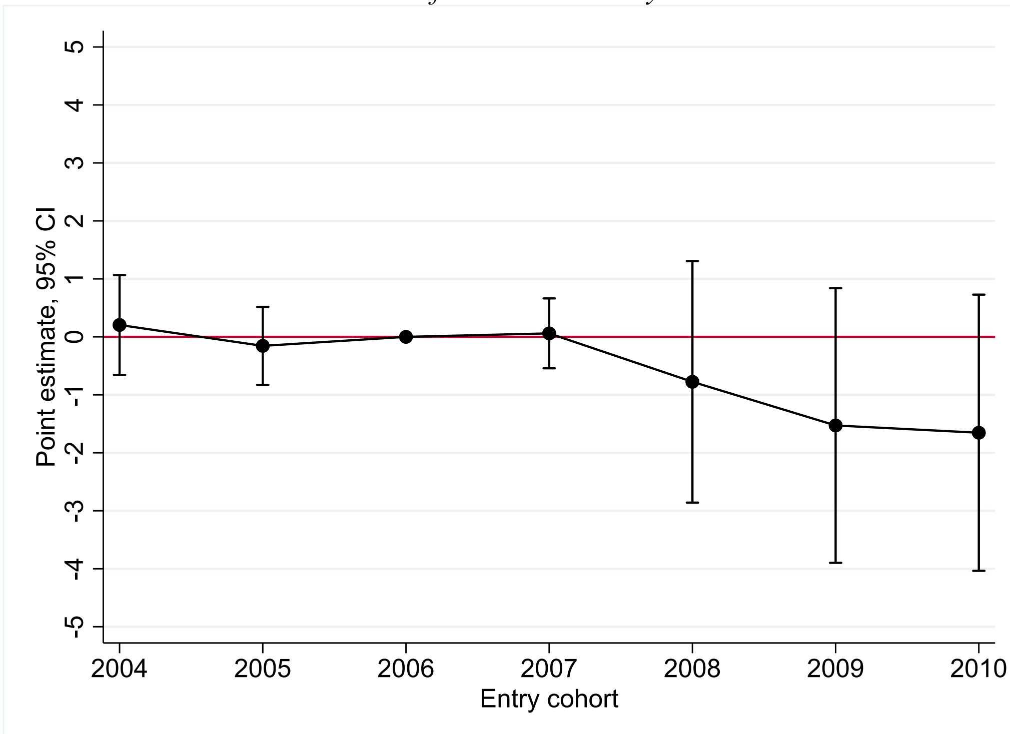
A. Federal borrowing limit



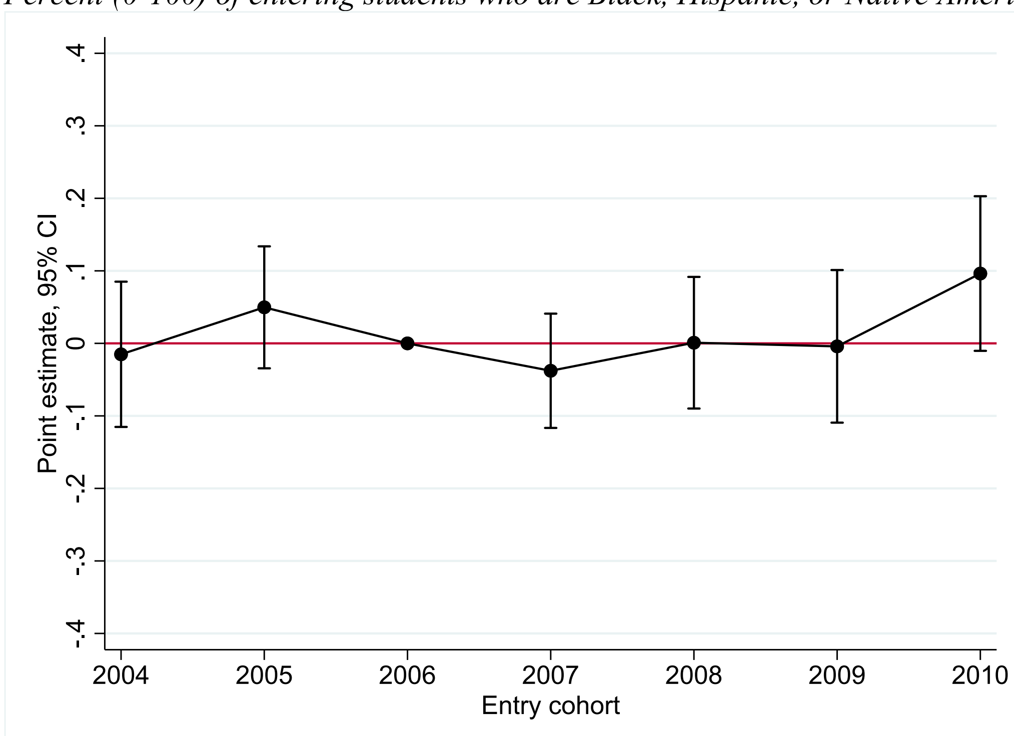
B. Grad PLUS loans



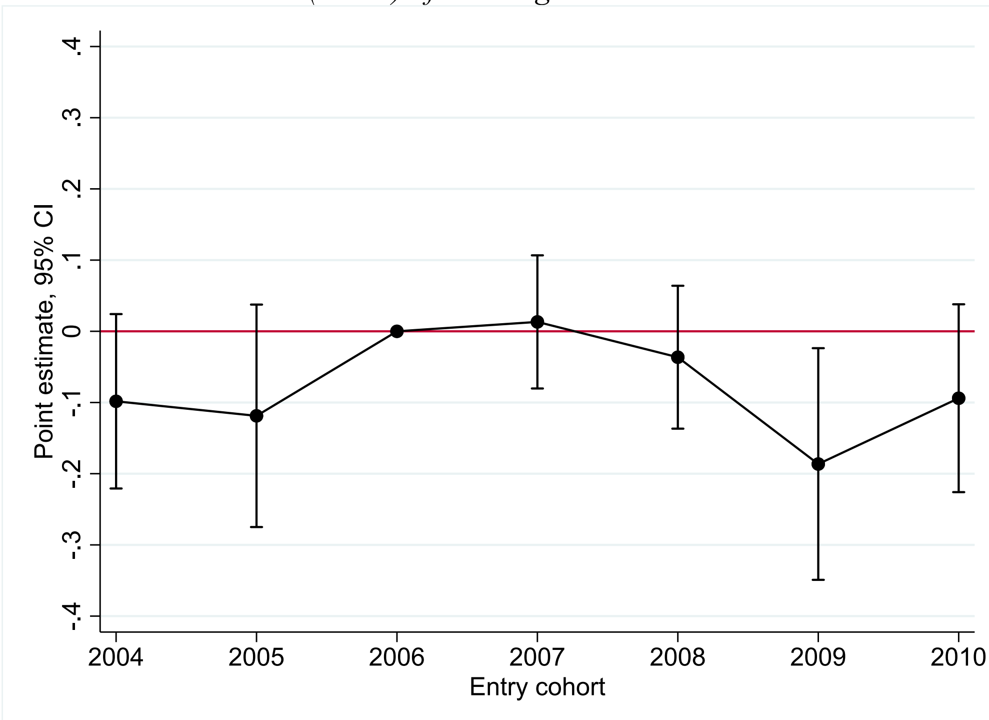
C. Number of students in entry cohort



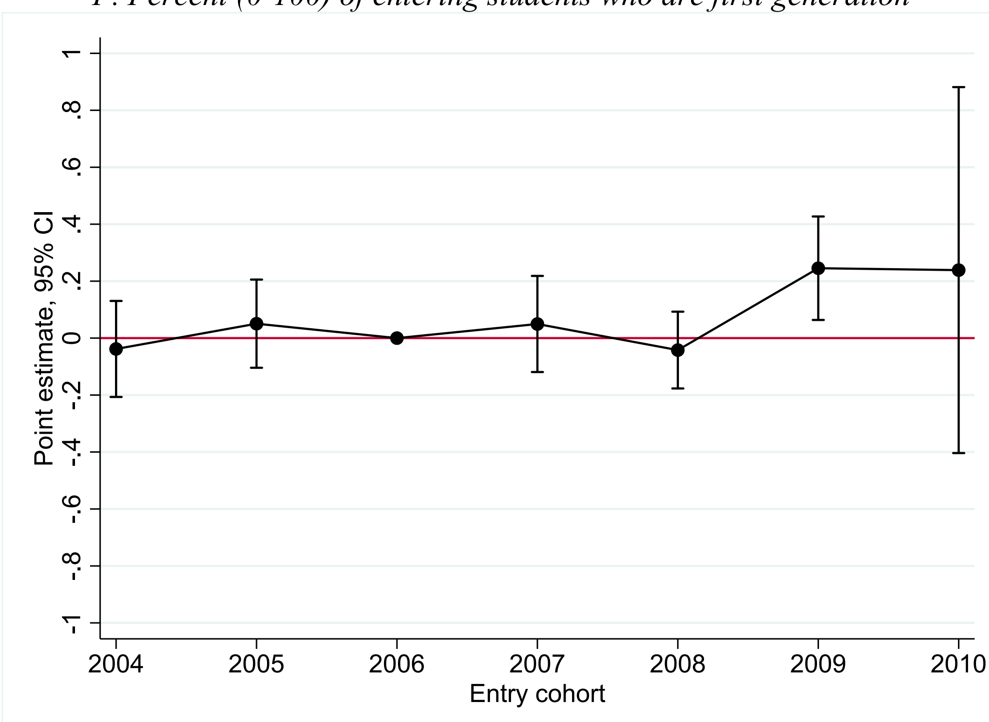
D. Percent (0-100) of entering students who are Black, Hispanic, or Native American



E. Percent (0-100) of entering students who are men

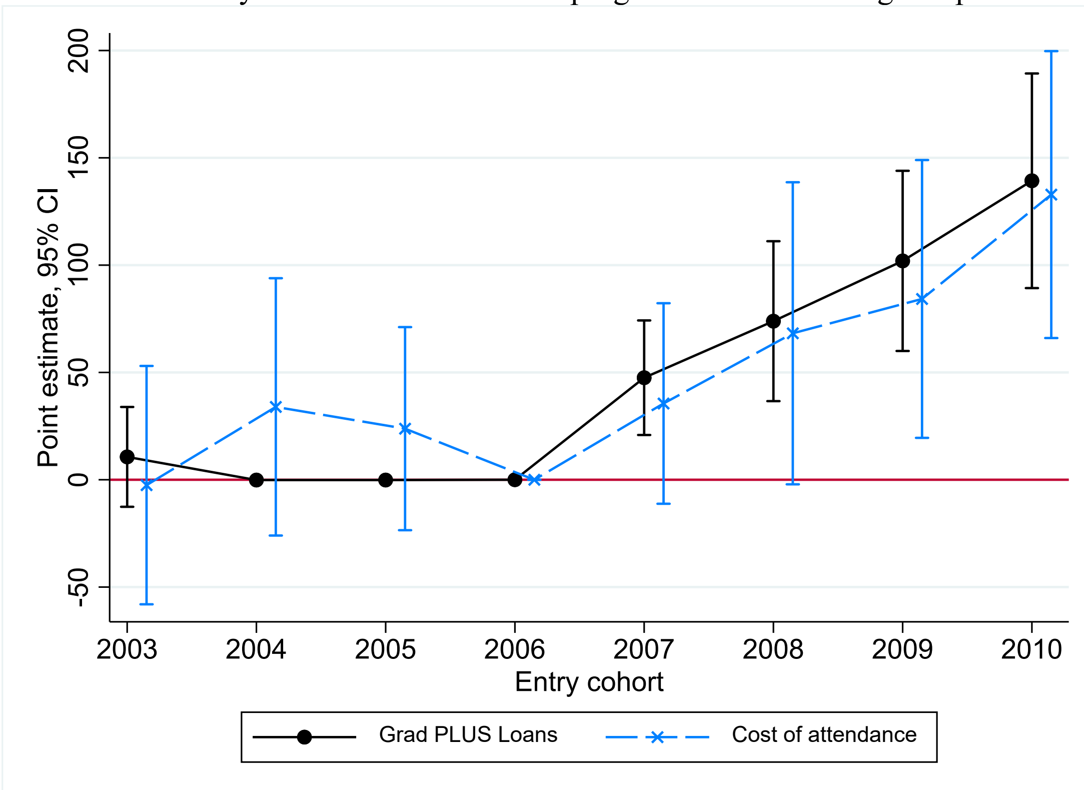


F. Percent (0-100) of entering students who are first generation



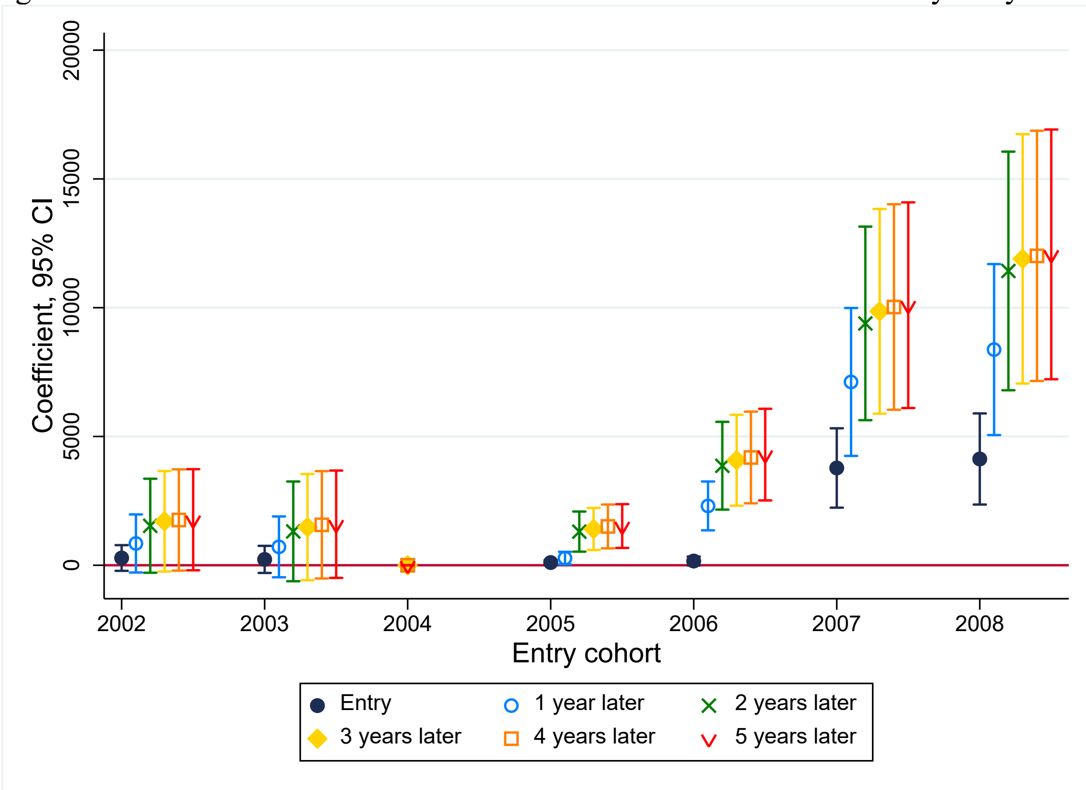
Notes: The sample includes graduate programs that had entering students in each of the 2004 through 2010 academic years and had at least 20 entering students who filed a FAFSA in 2004 through 2006. Point estimates and 95% confidence intervals from regressions of federal loan limits (Panel A), average 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), men (Panel E), or first-generation (Panel F) 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 4: 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



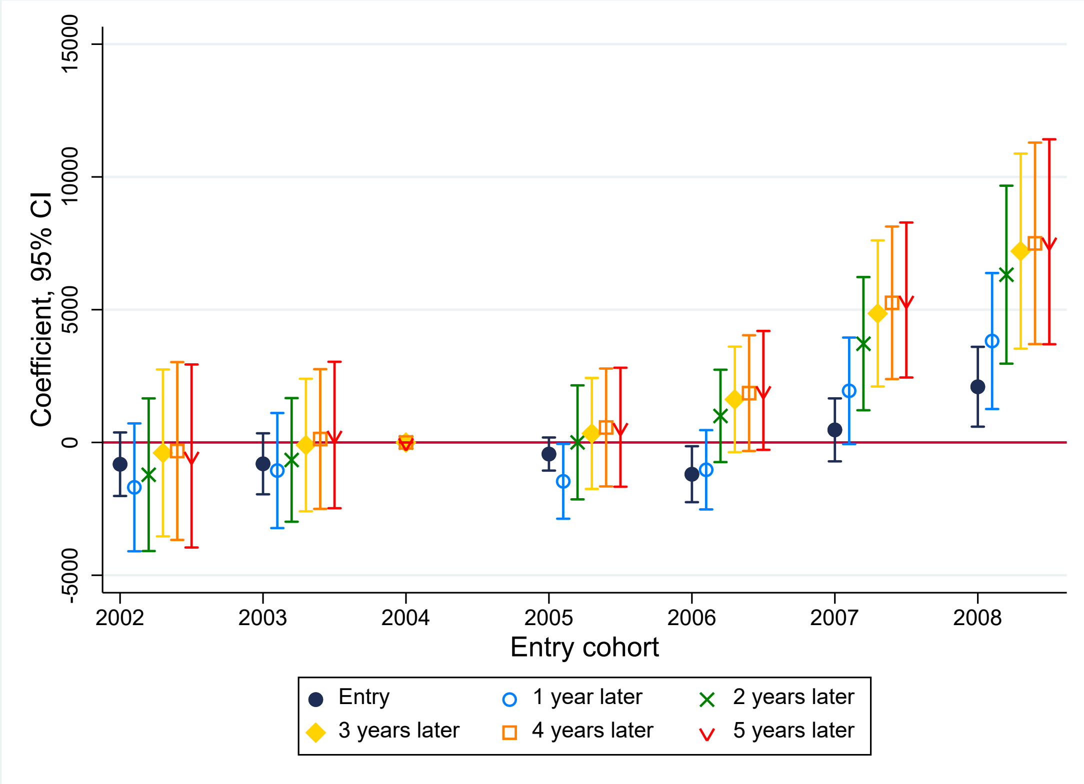
Notes: The sample includes a balanced panel graduate programs with enrollment in the 2003 through 2010 academic years and at least 20 federal aid recipients enrolled per year, on average, between 2003 and 2006. Point estimates and 95% confidence intervals from regressions of average Grad PLUS loans per 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.

Figure 5: Effects on constrained students' cumulative Grad PLUS loans by entry cohort



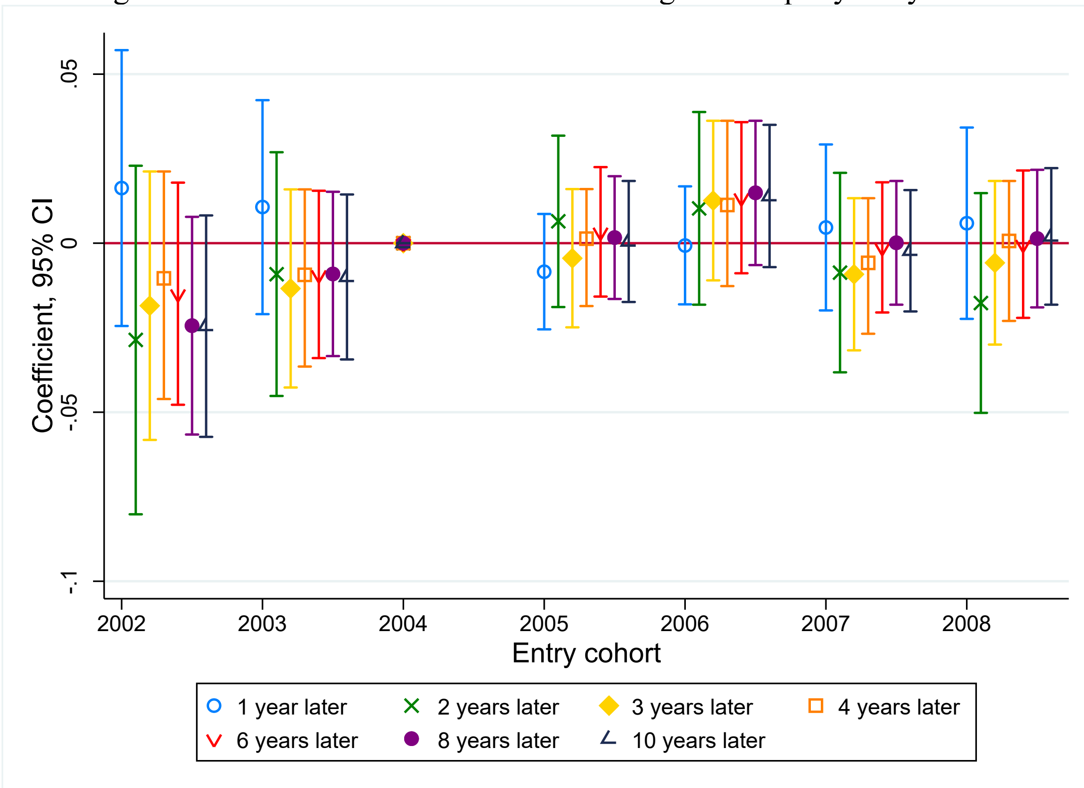
Notes: The sample includes first-time graduate students who borrowed in their first year of enrollment. Point estimates and 95% confidence intervals from regressions of cumulative Grad PLUS loans at the specified number of years since entry on an interaction between entry cohort and an indicator for 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 6: Effects on constrained students' cumulative student loans from all sources



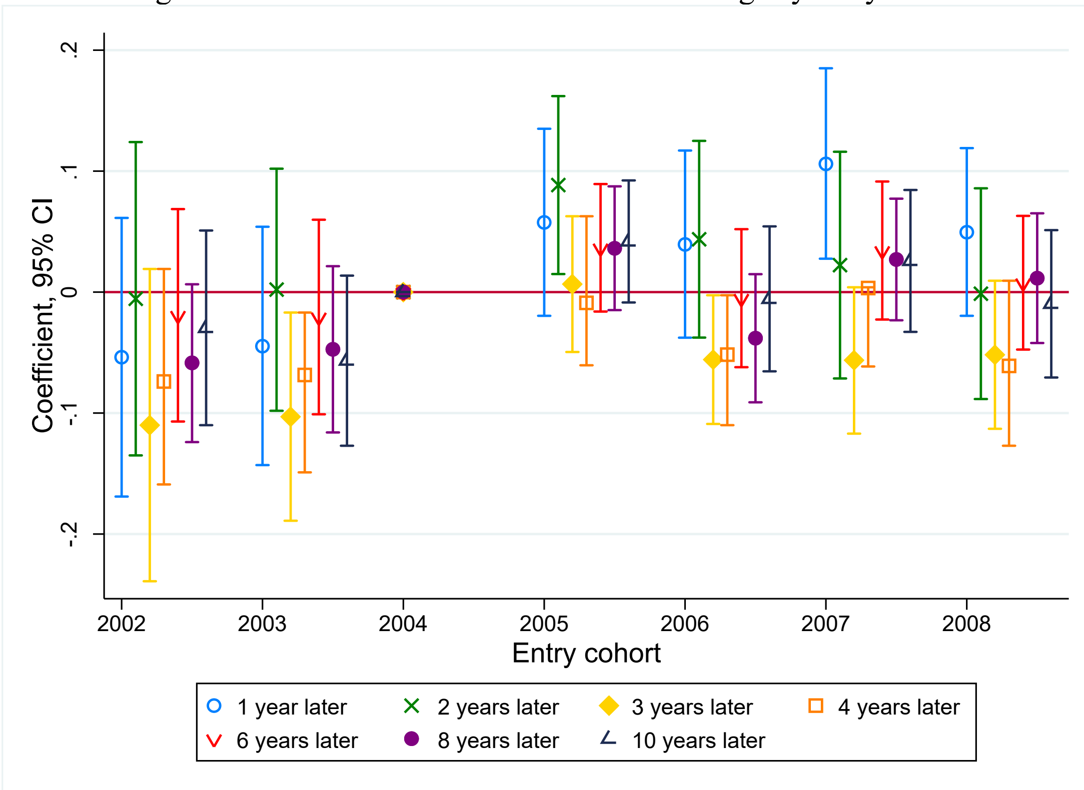
Notes: The sample includes first-time graduate students who borrowed in their first year of enrollment. Point estimates and 95% confidence intervals from regressions of cumulative student loans at the specified number of years since entry on an interaction between entry cohort and an indicator for being 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 7: 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 8: 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.

Table 1: Characteristics of first-time graduate students

	(1) Pre-Grad PLUS (2002-2006)	(2) Post Grad PLUS (2007-2010)	(3) All
Observations	245,774	212,544	458,318
Female	0.578	0.576	0.577
Race/ethnicity/nativity			
API	0.056	0.065	0.060
Black	0.096	0.103	0.099
Hispanic	0.161	0.166	0.163
White	0.555	0.537	0.547
International	0.132	0.130	0.131
Age (in yrs)	30.2	29.5	29.9
Texas Resident	0.769	0.766	0.768
Degree receipt within			
2 years	0.443	0.507	0.472
4 years	0.625	0.694	0.657
6 years	0.674	0.737	0.703
8 years	0.694	0.752	0.721
Broad field of study			
Education	0.250	0.233	0.242
Health	0.142	0.156	0.148
Business	0.136	0.157	0.146
Engineering	0.075	0.075	0.075
Law	0.053	0.052	0.052
Social services	0.034	0.035	0.034
Computer science	0.029	0.027	0.028
Academic doctoral	0.166	0.152	0.159
STEM field of study	0.133	0.135	0.134
Sector of institution			
Health-related	0.077	0.082	0.080
Flagship	0.144	0.117	0.132
R1	0.290	0.276	0.283
Other	0.489	0.525	0.506
Any loans			
Stafford	0.318	0.401	0.356
PLUS	--	0.039	0.019
Private	0.024	0.016	0.020
From any source	0.319	0.404	0.359
Constrained borrowers	0.096	0.156	0.124
Amount borrowed (2018$)			
Total loans	$6,258	$8,285	$7,198
Federal Stafford Loans	$5,814	$7,292	$6,499
Federal PLUS loans	$14	$663	$315
Federal Perkins loans	$91	$55	$74
State loans	$19	$56	$36
Private and other loans	$320	$220	$274
Total grants (2018$)	$814	$1,721	$1,234
Earnings (2018$)	$32,292	$31,426	$31,891
EFC (2018$)	$7,561	$8,809	$8,258
Cost of attendance (2018$)	$28,921	$31,149	$30,177

Notes: Sample is limited to first-time graduate students who enrolled in the 2002 through 2010 academic years. API = Asian or Pacific Islander. STEM field of study based on the DHS definition. Constrained borrowers are students with federal loans at or above the Stafford Loan limit in the academic year. EFC = expected family contribution.

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

		Percent (0-100%) of entering students who are:						
	(1) Enrollment	(2) Black	(3) Hispanic	(4) API	(5) White	(6) Internl	(7) Men	(8) First gen
A.OLS estimates								
Projected limit increase ($1k) x post	-1.0	-0.01	0.02	0.02	0.08	-0.03	-0.004	0.12
	(0.8)	(0.02)	(0.03)	(0.02)	(0.09)	(0.06)	(0.03)	(0.09)
B. IV estimates								
Federal loan limit ($1k)	-1.0	-0.01	0.02	0.02	0.07	-0.03	-0.003	0.11
	(0.8)	(0.02)	(0.02)	(0.01)	(0.08)	(0.06)	(0.03)	(0.08)
95% CI	[-2.5 ,0.5]	[-0.04 ,0.02]	[-0.03 ,0.06]	[-0.01 ,0.04]	[-0.08 ,0.22]	[-0.14 ,0.08]	[-0.06 ,0.05]	[-0.04 ,0.27]
C. Pre Grad PLUS mean	135.6	8.1	16.4	5.9	55.3	11.8	41.5	39.8

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 = 2,380). 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 (col (1) F-stat = 773, col (2)-(8) F-stat = 675). 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 (8) estimates weighted by the size of the entering cohort. Robust standard errors, clustered at the program level, in parentheses.

Table 3: Heterogeneous effects of projected increases in federal loan limits on enrollment and 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	(8) 1st gen
A. Capacity								
Projected limit increase ($1k) x Post								
x Low spread	-2.3	-0.001	0.02	-0.005	0.09	-0.02	0.01	0.15
	(1.6)	(0.02)	(0.03)	(0.02)	(0.10)	(0.07)	(0.03)	(0.11)
x High spread	1.0	-0.06	0.001	0.06	-0.01	0.05	-0.08	0.16
	(1.0)	(0.06)	(0.07)	(0.05)	(0.10)	(0.07)	(0.05)	(0.17)
Test of equality: *p* -value	0.072	0.339	0.788	0.207	0.526	0.487	0.152	0.954
Observations	2,380	2,380	2,380	2,380	2,380	2,380	2,380	2,376
B. Admissions rate								
Projected limit increase ($1k) x Post								
x acceptance rate < 66%	-1.0	0.02	0.04	0.001	-0.01	-0.0002	-0.03	0.03
	(0.9)	(0.02)	(0.03)	(0.02)	(0.09)	(0.07)	(0.04)	(0.11)
x acceptance rate >= 66%	0.6	0.07	0.002	-0.08	-0.19	0.61	0.01	0.64
	(3.8)	(0.09)	(0.07)	(0.10)	(0.19)	(0.29)*	(0.19)	(0.79)
Test of equality: *p* -value	0.682	0.618	0.638	0.425	0.390	0.042	0.853	0.449
Observations	2,065	2,065	2,065	2,065	2,065	2,065	2,065	2,061
C. Institution type								
Projected limit increase ($1k) x Post								
x Health-related	0.2	-0.19	-0.08	0.07	0.23	-0.06	-0.07	0.06
	(0.4)	(0.07)*	(0.1)	(0.07)	(0.2)	(0.1)	(0.1)	(0.2)
x Flagship	-6.8	-0.01	-0.13	0.04	0.22	0.00	0.002	0.10
	(4.0)+	(0.04)	(0.05)**	(0.04)	(0.24)	(0.31)	(0.11)	(0.26)
x R1	0.05	0.06	0.10	0.02	0.06	0.00	0.03	(0.21)
	(1.1)	(0.04)	(0.03)**	(0.04)	(0.10)	(0.06)	(0.08)	(0.18)
x Other	-1.2	-0.01	0.03	0.01	-0.07	0.02	0.002	-0.13
	(0.9)	(0.02)	(0.04)	(0.01)	(0.05)	(0.02)	(0.02)	(0.14)
Test of equality: *p* -value	0.184	0.043	0.001	0.003	0.847	0.280	0.733	0.891
Observations	2,380	2,380	2,380	2,380	2,380	2,380	2,380	2,376

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 from regressions of the outcome on an interaction between post-Grad PLUS entry cohort, the projected federal loan limit increase, and the indicated dimension of heterogeneity. All specifications also include entry cohort and program fixed effects, fully interacted with the indicated dimension of heterogeneity. The dimension of heterogeneity in Panel A is a proxy for a program's capacity to expand ("spread"), equal to the difference between the largest and smallest entry cohort divided by the average entry cohort size (all measured over the 2004 through 2006 academic years). The dimension of heterogeneity in Panel B is pre-Grad PLUS program admissions rates. The dimension of heterogeneity in Panel C is institution type. Columns (2) through (8) estimates weighted by the size of the entering cohort. Robust standard errors, clustered at the program level, in parentheses; ** $p < 0.01$, + $p < 0.1$.

Table 4: 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 x post	88.1	60.4	3.6	-36.7
	(18.4)**	(32.0)+	(3.5)	(13.6)**
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. Observations weighted by the average number of federal aid recipients between 2003 and 2006. Robust standard errors, clustered at the program level, in parentheses; ** $p < 0.01$, + $p < 0.1$.

Table 5: OLS and IV estimates of the effect of Grad PLUS on program prices and financial aid

	(1) COA	(2) FTFY COA	(3) Grants	(4) Tuit waivers	(5) Net price
A. OLS estimates					
% constrained x post	66.4	62.7	25.6	2.0	38.8
	(23.5)**	(18.9)**	(15.2)+	(3.4)	(33.5)
Observations	2,336	2,336	2,336	2,336	2,336
B. IV estimates					
Federal loans	1.099	1.038	0.423	0.033	0.642
	(0.478)*	(0.464)*	(0.414)	(0.061)	(0.354)+
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. Panel A contains point estimates from OLS 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). Panel B contains point estimates from IV regressions in which average federal student loans per student is the endogenous regressor and an interaction between post-Grad PLUS and the percent of all enrolled students who were constrained at baseline is the excluded instrument. Regressions also include academic year and program fixed effects. 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. Observations weighted by the average number of federal aid recipients between 2003 and 2006. Robust standard errors, clustered at the program level, in parentheses; ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table 6: Heterogeneous effects of Grad PLUS on program prices and financial aid

	(1) Grad PLUS loans	(2) Total Fed. loans	(3) COA	(4) Grants	(5) Net price
A. Capacity					
% constrained*Post					
x Low spread	95.9	70.5	65.3	30.0	34.0
	(19.0)**	(36.5)+	(24.4)*	(17.4)+	(38.1)
x High spread	24.1	-2.7	-6.2	-2.4	-2.3
	(7.7)**	(10.9)	(21.0)	(4.8)	(20.8)
Test of equality: *p* -value	0.001	0.055	0.034	0.079	0.419
Observations	2,336	2,336	2,336	2,336	2,336
B. Admissions rate (discrete)					
% constrained*Post					
x acceptance rate < 66%	154.0	129.7	191.7	18.3	159.7
	(20.1)**	(49.9)*	(26.7)**	(14.2)	(33.6)**
x acceptance rate >= 66%	9.1	215.1	9.6	50.8	-51.3
	(4.6)+	(77.5)**	(151.3)	(26.4)+	(124.5)
Test of equality: *p* -value	<0.001	0.359	0.241	0.272	0.105
Observations	2024	2024	2024	2024	2024
C. Institution type					
% constrained*Post					
x Health-related	35.5	-35.3	-14.3	7.0	-23.8
	(13.6)*	(27.5)	(45.8)	(10.6)	(43.2)
x Flagship	137.8	128.2	136.1	4.8	115.7
	(0.2)**	(2.5)**	(21.1)**	(10.7)	(29.0)**
x R1	111.7	89.0	67.1	-4.9	69.3
	(25.4)**	(33.9)*	(36.7)+	(15.1)	(53.6)
x Other	80.7	43.7	72.9	38.1	34.3
	(24.6)**	(42.9)	(29.3)*	(20.1)+	(43.4)
Test of equality: *p* -value	<0.001	<0.001	0.021	0.392	0.063
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 the outcome on an interaction between post-Grad PLUS, the percent of students who were constrained at baseline, and the indicated dimension of heterogeneity (see Table 3 notes for additional details). Regressions also include academic year and program fixed effects, fully interacted with the indicated dimension of heterogeneity. Observations weighted by the average number of federal aid recipients between 2003 and 2006. Robust standard errors, clustered at the program level, in parentheses; ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table 7: 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	55.3	46.1	29.5	9.4
	(13.0)**	(25.8)+	(16.9)+	(38.9)
Observations	1770	1770	1770	1770
B. Black				
% constrained*Post	101.5	88.5	16.8	39.7
	(22.2)**	(34.5)*	(31.8)	(45.3)
Observations	2111	2111	2111	2111
C. Hispanic				
% constrained*Post	88.3	55.3	29.5	16.7
	(20.8)**	(36.3)	(22.5)	(42.9)
Observations	2240	2240	2240	2240
D. White				
% constrained*Post	74.0	54.2	37.4	8.0
	(16.4)**	(26.1)*	(19.4)+	(44.4)
Observations	2286	2286	2286	2286

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 with the indicated demographic group 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. Observations weighted by the average number of federal aid recipients in the indicated demographic group between 2003 and 2006. Robust standard errors, clustered at the program level, in parentheses; ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table 8: 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	115.2	74.1	21.4	21.0
	(25.5)**	(40.1)+	(22.5)	(36.0)
Observations	2319	2319	2319	2319
B. Did not receive Pell as undergrad				
% constrained*Post	94.7	78.0	28.4	37.0
	(20.0)**	(36.1)*	(17.3)	(37.6)
Observations	2336	2336	2336	2336
C. First generation college student				
% constrained*Post	104.3	84.1	27.6	41.2
	(22.6)**	(40.3)*	(21.8)	(39.3)
Observations	2336	2336	2336	2336
D. College educated parent				
% constrained*Post	114.7	83.8	31.0	33.2
	(22.5)**	(40.3)*	(20.5)	(39.5)
Observations	2319	2319	2319	2319
E. EFC < median				
% constrained*Post	111.2	90.4	29.5	41.7
	(23.8)**	(39.7)*	(20.7)	(39.2)
Observations	2334	2334	2334	2334
F. EFC > median				
% constrained*Post	99.5	73.2	29.5	15.5
	(21.6)**	(38.0)+	(19.5)	(31.9)
Observations	2327	2327	2327	2327

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. Point estimates from regressions of average loans, grants, or price per student in the indicated demographic group 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. 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. Net price equals COA minus grants and tuition waivers. Regressions also include academic year and program fixed effects. Observations weighted by the average number of federal aid recipients in the indicated demographic group between 2003 and 2006. Robust standard errors, clustered at the program level, in parentheses; ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table 9: 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	0.406	0.289	0.369	0.403
	(0.532)	(0.399)	(0.374)	(0.404)
x Does not have characteristic	0.687	0.364	0.328	0.327
	(0.609)	(0.342)	(0.357)	(0.324)
Test of eq (p-val)	0.062	0.512	0.583	0.511
Observations	4,614	4,655	4,655	4,661

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 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.

Table 10: 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	1994	4287	6001	6243	6332	6388	6410
	(398)**	(868)**	(1246)**	(1279)**	(1281)**	(1280)**	(1278)**
Dep var mean (cons, pre)	$13	$15	$21	$98	$148	$189	$251
B. Federal loans							
Constrained x treated cohort	1207	3275	5952	6593	6806	6861	6877
	(433)**	(888)**	(1291)**	(1475)**	(1544)**	(1580)**	(1611)**
Dep var mean (cons, pre)	$26,046	$47,218	$60,049	$63,969	$65,770	$66,965	$67,854
C. Private loans							
Constrained x treated cohort	-572	-1802	-2740	-2958	-2966	-2960	-2959
	(253)*	(587)**	(825)**	(901)**	(896)**	(894)**	(893)**
Dep var mean (cons, pre)	$2,362	$4,675	$5,803	$5,932	$5,981	$5,999	$6,007
D. State loans							
Constrained x treated cohort	14	43	60	79	90	97	99
	(28)	(56)	(84)	(87)	(89)	(89)	(89)
Dep var mean (cons, pre)	$108	$206	$288	$293	$293	$297	$298
E. Total loans							
Constrained x treated cohort	650	1515	3271	3714	3931	3998	4017
	(383)+	(699)*	(955)**	(1062)**	(1124)**	(1149)**	(1175)**
Dep var mean (cons, pre)	$28,516	$52,099	$66,140	$70,193	$72,043	$73,260	$74,159
F. Any federal PLUS loans in year							
Constrained x treated cohort	0.112	0.133	0.109	0.013	0.003	0.001	0.001
	(0.019)**	(0.027)**	(0.032)**	(0.005)*	(0.001)*	(0.001)	(0.001)
Dep var mean (cons, pre)	--	--	--	--	--	--	--
G. Any federal PLUS loans to date							
Constrained x treated cohort	0.112	0.167	0.202	0.202	0.202	0.202	0.203
	(0.019)**	(0.028)**	(0.034)**	(0.034)**	(0.034)**	(0.034)**	(0.034)**
Dep var mean (cons, pre)	--	--	--	--	0.011	0.013	0.015

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 from the source indicated in the panel heading (Panels A through E), the probability of taking out Grad PLUS loans in a given year 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, age, and indicators for race/ethnicity, gender, college educated parents and enrollment in fall and spring, and constrained status. Robust standard errors, clustered at the program level, in parentheses; ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table 11: The effect of Grad PLUS on constrained students' educational attainment and labor market outcomes

Years since entry =	1	2	3	4	5	6	7	8	9	10
A. Cumulative years enrolled (N = 117,954)										
Constrained x treated cohort	0.01	0.02	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.05
	(0.01)	(0.02)	(0.02)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Dep var mean (cons, pre)	1.9	2.5	2.7	2.8	2.9	3.0	3.0	3.1	3.1	3.1
B. Cumulative credit hours attempted (N = 117,954)										
Constrained x treated cohort	0.35	0.98	1.14	1.32	1.47	1.57	1.60	1.61	1.61	1.59
	(0.43)	(0.50)*	(0.63)+	(0.67)*	(0.69)*	(0.72)*	(0.73)*	(0.75)*	(0.76)*	(0.77)*
Dep var mean (cons, pre)	32.80	41.08	43.39	44.79	45.79	46.55	47.17	47.66	48.06	48.4
C. Any graduate degree receipt (N = 117,954)										
Constrained x treated cohort	-0.006	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 (cons, pre)	0.280	0.675	0.769	0.799	0.813	0.822	0.827	0.831	0.835	0.837
D. Any earnings (N = 117,954)										
Constrained x treated cohort	0.012	0.020	0.017	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 (cons, pre)	0.717	0.706	0.712	0.69	0.669	0.651	0.637	0.624	0.614	0.605
E. 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 (cons, pre)	9.78	10.12	10.68	10.92	11.00	11.05	11.10	11.14	11.18	11.20
Observations	87,555	85,496	88,256	86,125	84,103	82,406	80,802	79,520	78,292	77,330

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), the probability of any degree receipt (Panel C), having earnings in a UI-covered sector in Texas (Panel D), or ln(annual earnings) (Panel E) 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; * $p < 0.05$, + $p < 0.1$.