Debt and Human Capital: Evidence from Student Loans

Vyacheslav Fos Andres Liberman Constantine Yannelis*

January 2017†

Abstract

This paper investigates the dynamic relation between debt and investments in human capital. We document a negative causal effect of the level of undergraduate student debt on the probability of enrolling in a graduate degree for a random sample of the universe of federal student loan borrowers in the US. We compare students (i) within school and cohort, and (ii) across cohorts within the same school at the time of a large tuition change. The latter strategy exploits the fact that students who face a tuition increase in earlier grades end up with significantly more debt than students who face the same tuition increase in later grades. We find that $4,000 in higher debt causes a two percentage point reduction in the probability of enrolling in graduate school relative to a mean of 12%. Further results suggest this effect is largely driven by credit constraints, is monotonically weaker with family income, and is attenuated for students who had compulsory personal finance training in high school. The results highlight an important trade off associated with debt-financing of human capital, and inform the debate on the effects of the large and increasing stock of student debt in the US.

Keywords: Student Debt, Human Capital, Postgraduate education, Credit constraints, Debt Overhang
JEL codes: D14, H52, H81, J24, I23

*Fos is at Boston College, email: fos@bc.edu. Liberman is at New York University, email: aliberma@stern.nyu.edu. Yannelis is at New York University, email: cyanneli@stern.nyu.edu. We thank Harrison Hong, Caroline Hoxby, Virgiliu Midrigan, Holger Mueller, Philipp Schnabl, Phil Strahan, Johannes Stroebel and seminar participants at NYU and Boston College. All errors and omissions are ours only. The views expressed in this paper solely reflect the views of the authors and do not reflect the views of the Treasury or any other organization.

†First version: January 2017.

I. Introduction

Student debt is currently the largest non-housing liability for U.S. households. As of the first quarter of 2016, U.S. households held approximately $1.4 trillion in student debt, more than credit card and auto loan liabilities. Moreover, this amount represents a $1 trillion increase since the first quarter of 2004.[1] This fast increase in student debt has attracted the interest of policymakers and academics, as these large levels of debt may alter students' future consumption and investment decisions.[2]

The increase in student debt may have particularly important effects on the dynamics of human capital accumulation. Indeed, investments in human capital, in particular in education, are one of the main drivers of economic growth (Goldin and Katz (2008)). The idea that debt may affect future investments in physical capital has a long history in the corporate finance literature (e.g., Myers (1977), Whited (1992), Albuquerque and Hopenhayn (2004)). In this paper we study whether this effect extends to investments in human capital. In particular, we ask: does the level of undergraduate student debt causally affect the probability that an individual enrolls in a postgraduate degree?

To answer this question we exploit data from the National Student Loan Data System (NSLDS) that contains all federally guaranteed student loans issued under Title IV of the Higher Education Act of 1965.[3] We work with a 4% random sample of the NSLDS, which includes data on student debt and postgraduate enrollment, as well as demographic characteristics such as age and family income, and education specific variables such as college, year of graduation, and academic grade during borrowing years. These data are broad, encompassing more than 90% of all student debt in the U.S. across all types of schools and degrees from 1992 to 2015, including private for profit, private non-profit, and public schools

[1] See https://www.newyorkfed.org/microeconomics/hhdc.html, as well as Lee, Van der Klaauw, Haughwout, Brown, and Scally (2014) and Lochner and Monge-Naranjo (2015).

[2] See e.g., estimates of the effects of student debt on housing (Cooper and Wang (2014), Mezza, Ringo, Sherlund, and Sommer (2016)), job choice (Rothstein and Rouse (2011)), job search (Ji (2016)), risk (Palacios (2014)) and marriage (Gicheva et al. (2011))).

[3] See Looney and Yannelis (2015a) for a detailed description of the data.

across the country.

We start by documenting that a higher level of undergraduate debt is associated with a lower probability of enrolling in graduate school.[4] This effect is economically large and statistically significant: in a specification saturated with calendar year and school by cohort fixed effects, $4,000 in higher debt at graduation (equivalent to 0.34 standard deviations) reduces the probability that an individual enrolls in graduate school in the following eight years by 1.2 percentage points, a ten per cent reduction off a baseline 12% probability.

Yet, even a saturated OLS regression may produce biased estimates of the causal effect of the level of student debt on an individual's propensity to enroll in postgraduate school. For example, individuals who expect their future earnings to be high may be more likely to enroll in graduate school and to finance their undergraduate education with debt (a positive omitted variable bias). To address this concern, we exploit heterogeneous exposure to large changes in headline tuition at the school level as an exogenous source of variation in the level of undergraduate student debt. Previous work has identified school-level tuition changes as an important determinant of the rise in the aggregate level of student debt (Baum (2015), Mezza, Ringo, Sherlund, and Sommer (2016), Looney and Yannelis (2015a)). However, a comparison of students who attend schools where tuition changes is likely to suffer from selection bias. For example, schools that increase tuition are also able to provide a better education (a causal effect) and to potentially attract better students (a selection effect). Thus, we identify off variation in the level of debt at graduation for students who are already enrolled in the *same* undergraduate school in *different* cohorts during the year of a large tuition change. Intuitively, a large tuition change should have the largest effect on the debt of the cohort that just finished their first year, and monotonically smaller effects for cohorts that just finished their second, third, and fourth years, while it should have no effect on the debt of cohorts that already graduated.

[4]In all our analysis we restrict the sample to borrowers with undergraduate loans who attain a four year undergraduate degree, and thus are eligible to attend postgraduate school.

As a first stage, we validate the power of our identification strategy by showing a negative relationship in the level of undergraduate debt and the student's cohort at the time of a large tuition change–the cohort that just finished first year, the cohort that just finished second year, and so on. Students exposed to a $4,000 tuition increase after the first year of their undergraduate degree, a typical large increase in tuition in our data, increase their debt by $600 more than students in their same school exposed to the same tuition increase in year six of their degree. In turn, the reduced form relationship between the probability of enrolling in a graduate degree and a student's cohort at the time of a large tuition change is positive and monotonic. Demographic and financial student-level characteristics that are observable at the time of enrolling in an undergraduate degree such as family income, number of children, and gender do not exhibit any relationship with the student's cohort at the time, which provides support for the conditional independence assumption underlying our identification strategy.

We instrument for the level of student debt using the variation in the effect of a tuition change across cohorts. Using this instrumental variables strategy, we find a large negative effect of the level of student debt on the probability that an individual attends graduate school. A $4,000 higher student debt reduces the probability that an individual attends graduate school by about two percentage points in the eight years following the completion of her undergraduate studies, again from a baseline of 12%. These results are robust to the inclusion of demographic and financial controls observable at the time of undergraduate debt application. To get a sense of the magnitude of this effect, consider the role of gender and children. For instance, women have a one percentage point higher probability of attending graduate school than men and having a child is associated with two percentage points lower probability of attending graduate school.

There are two distinct but not mutually exclusive mechanisms by which debt may reduce the probability that an individual invests in their own education. First, individuals with

more debt are likely to be tagged as riskier and face tighter credit constraints (Lochner and Monge-Naranjo (2011), Sun and Yannelis (2013)). Individuals generally can always borrow more federal student debt up to the regulatory limit set by the government, unless they are in default. Thus, for borrowers in good standing, any additional borrowing above and beyond the borrowing limit must be done from the private sector. In turn, an individual's existing stock of debt is likely to affect the capacity to borrow from the private sector. Moreover, higher levels of debt are also likely to induce more defaults (Yannelis (2016)), which also reduce access to both private and federal credit via a decrease in reputation (Lochner and Monge-Naranjo (2015), Liberman (2016), Dobbie, Goldsmith-Pinkham, Mahoney, and Song (2016)). Thus, individuals who want to invest in their education and obtain a postgraduate degree may be unable to do so because of credit constraints. Second, even if a post graduate degree represents a riskless investment with a positive net present value, an individual's existing level of debt may induce her to under-invest in her own human capital, reducing demand for a postgraduate education (following the analysis in Myers (1977) for investment by firms). This is because only part of the benefits from investing in a postgraduate degree are available to the investor: the rest benefits existing creditors. Moreover, because student debt is not dischargeable upon bankruptcy, default does not alleviate this concern.[5]

We first document that the size of the relationship between student debt and the probability of attending graduate school decreases monotonically by family income and is not statistically different from zero for the highest family income quintile. This suggests an unequal incidence of the effect we measure, but is consistent with both mechanisms: lower income students are both more likely to be credit constrained and more likely to be close to bankruptcy, increasing the incentive to underinvest. We perform three additional tests to differentiate between the credit constraints and the under-investment channels. First, we

[5]Debt may also affect an individual's performance at school, causally reducing the probability that the student is accepted as a postgraduate student (e.g., Mullainathan and Shafir (2013)). The opposite effect is also possible: students with more debt may become more focused and become better students. We cannot measure these effects because we have no information on courses taken or grades.

consider whether our results vary following increases in the federal student debt borrowing. If binding credit constraints are driving the negative correlation between debt and graduate enrollment, this effect should be smaller in the years immediately after limit increases, when students become less constrained. Supporting our conjecture, we find that the negative effect of student debt on the propensity to attend graduate school is attenuated following federally mandated increases in government student debt caps. Thus, this result supports the credit constraints channel.

Second, we exploit the 1998 federal law change concerning the treatment of student debt in personal bankruptcy. Whereas prior to 1998 student loans were dischargeable seven years after entering repayment, the 1998 law change made federal student loans indefinitely non-dischargeable in bankruptcy.[6] If the under-investment channel holds, the law change is expected to enhance the role of this mechanism and therefore strengthen the negative relation between debt and graduate enrollment. Indeed, after the law change, a bankrupt individual cannot discharge previous student debt to profit from future investments such as postgraduate education. We find that the law change is not associated with significant changes in the relation between the level of student debt and the probability of attending graduate school. Therefore, this result does not support the under-investment channel.

Third, we consider the role of financial education, which has been shown to significantly impact the debt behavior of young borrowers (Brown, Collins, Schmeiser, and Urban (2014), Brown, Grigsby, van der Klaauw, Wen, and Zafar (2016)). We conjecture that students who took personal finance courses in high school are less likely to be financially constrained (e.g., more aware of alternative sources of borrowing and better able to understand credit scores and their implications on future borrowing). Therefore, the credit constraints channel predicts a weaker relation between debt and graduate enrollment for financially educated students. Consistent with our conjecture, we find that the effect of undergraduate debt on graduate enrollment is strongly attenuated for borrowers who were required to take a

[6]See Yannelis (2016) for a discussion of student loan bankruptcy.

financial education course. Thus, this result supports the credit constraints channel.

Overall, the tests described above support the *credit constraints* channel as the main driver of the causal effect of student debt on postgraduate enrollment. Our results point to binding credit constraints that are exacerbated by student debt, whereby students cannot finance their graduate tuition and expenses above and beyond the federal student loans borrowing cap.[7] Moreover, our results suggest that mandatory high-school financial education may be a way to mitigate the role of credit constraints in the process of human capital accumulation, aside from more standard and potentially more expensive policies such as increasing federal grants or engaging in ex-post debt forgiveness programs.

Our paper contributes to several strands of the literature. First, we contribute to the literature that studies the consequences of the large and increasing stock of student liabilities.[8] Our paper contributes to this literature by focusing on investments in future education rather than consumption and shows that student debt plays an important role in the dynamic accumulation of human capital.

Our work also contributes to the literature on the returns to education and human capital (e.g., Goldin and Katz (2008), Carneiro, Heckman, and Vytlacil (2011), and Avery and Turner (2012)). Previous work has shown that, on average, returns to investments in education are high. For example, a postgraduate education is likely to have relatively large effects on individual-level earnings on average (e.g., Avery and Turner (2012)), and is likely to induce positive externalities (e.g., by increasing the supply of educated individuals to conduct research and development). The potential effects of debt on human capital accumulation and on earnings have important implications for growth, tax revenue and fiscal balances. Our results suggest that credit constraints matter for human capital accumulation and may lead

[7]Graduate students in the U.S. are likely to borrow to fund their studies: the proportion of graduate students who borrow is larger than the proportion of undergraduate students who borrow, and conditional on borrowing, the amount borrowed is also larger (Baum (2015)).

[8]E.g., see Gicheva et al. (2011), Lochner and Monge-Naranjo (2011), Rothstein and Rouse (2011), Cooper and Wang (2014), Mezza, Ringo, Sherlund, and Sommer (2016), and Brown, Grigsby, van der Klaauw, Wen, and Zafar (2016). A related study is Scott-Clayton and Zafar (2016), which measures the effect of merit-based aid on outcomes that include future earnings and debt.

to sub-optimal level of investment in postgraduate degrees. Moreover, we find a negative and monotonic relation between family income and the effect of student debt on the probability of attending graduate school. Since low family income students are least likely to over-invest in education, this result further supports the conclusion that large student debt may lead to sub-optimal level of investment in postgraduate degrees.

Third, our paper contributes to the literature in macroeconomics that studies the dynamics of human capital accumulation (e.g., Galor and Moav (2004), Lochner and Monge-Naranjo (2011), and Cordoba and Ripoll (2013)). Our paper shows that financing frictions play an important role in human capital accumulation, a point that the macro literature has not thus considered.

The rest of the paper is organized as follows. In Section II we describe the institutional background for student loans in the U.S. and our data. In Section III we present our empirical tests and results. In Section IV we explore heterogeneous effects to uncover the mechanism that underlies our main result. We conclude in Section V.

II. Student Loan Data

Student loans are currently the largest source of household debt in the United States, save mortgages. The oustanding volume in 2012 was approximately $1.3 trillion, with the vast majority of student loan being disbursed by or guaranteed by the federal government. Interest rates are set by congress and generally do not vary for borrowers within the same cohort, degree and loan type.[9] Over 40 million US households have student loan debt and in 2012 71% of all students took on debt fo finance their college education. Approximately 40% of all debt is held by graduate and professional students, who tend to have higher balances (Looney and Yannelis (2015b)). Student loan differs from other types of consumer debt in a number of ways, for example, student loan is almost completely non-dischargeable in

[9]See Cox (2016) for a discussion of student loan interest rates.

bankruptcy.

The main data source for our study is the National Student Loan Data System, henceforth referred to the the NSLDS. The NSLDS is the main database that is used to administer federal direct and federally guaranteed student loans, which comprise the vast majority of student loans in the United States.[10] The data comprises billions of loan observations for over 70 million student loan borrowers since 1969, and is used in administrative tasks such as tracking loans disbursed and determining eligibility for different loan and repayment plans, as well as tracking defaulted borrowers and determining eligibility for special repayment plans. The analysis sample is constructed using a 4% random sample of the NSLDS. The sample is an annual panel, and is drawn using permutations of the last three digits of a borrower's identification to ensure that the same borrowers can be followed over time.

The NSLDS contains demographic and other data from the Free Application for Federal Student Aid (FAFSA) form, which all students who receive federal student loans are required to fill out. We obtain information from the last FAFSA filed by students. All recipients of federal student loans are required to fill out the FAFSA form. Data on state level financial education requirements is obtained from Brown, Collins, Schmeiser, and Urban (2014) and merged to our main data based on students' home states address, obtained from the FAFSA form. We obtain tuition data at the school level from the Integrated Postsecondary Education Data System (IPEDS) operated by the Department of Education.[11] Tuition data is for Title IV eligible institutions' list tuition. Large tuition changes are defined as increases or decreases of 50% of more in one academic year. Figure 1 plots the yearly time-series distribution of these large tuition increases, and suggests that, although there is some cyclicality, these are not concentrated in one particular year or one phase of the business cycle. Debt, tuition and income variables are winsorized at the 99% level.

[10] In 2008 the Department of Education estimated that 92% of outstanding student loans are either federal direct loans or federally guaranteed loans. All such loans are in the NSLDS.

[11] The borrower match rate is 88%, with match rates increasing ovver time. In 2008 we are able to match 92% of schools, with coverage being above 95% at all institution types except for-profits.

Data on institutional selectivity is obtained from Barron's Profile of American Colleges (2008). Institutions are classified as not competitive, less competitive, competitive, very competitive, highly competitive and most competitive based primarily on the fraction of applicants admitted. The majority of for-profits and community colleges are classified as non-competitive. Borrowers' institutions are identified by the last institution that they attended in the case of enrollment spells as multiple types of institutions. Looney and Yannelis (2015a) provide further information about the NSLDS as well as how variables are recorded from alternative data sources.

We measure graduate student enrollment from the NSLDS. We restrict the sample to borrowers with undergraduate loans who attain a four year undergraduate degree, and thus are eligible to attend postgraduate school. To ensure comparability of borrowers in different cohorts, the main outcome variable is an indicator of whether a borrower enrolls in graduate school within eight years of entry.[12] Our analysis sample also includes borrowers who enter into the NSLDS after 1987 and who enter repayment before 2009. After these two restrictions, our analysis dataset includes 265,006 individuals. All dollar figures are measured in 2014 dollars.

Table I displays selected summary statistics for the analysis dataset. We define undergraduate borrowing amounts as the sum of all undergraduate loans outstanding in the final year in which a borrower is enrolled in undergraduate studies.[13] Individuals in our sample have a 12% probability of enrolling in a graduate degree in the eight years following graduation. Average debt at graduation is $18,560. In terms of demographics, 41% of our sample is female, which suggests that male are more likely to borrow among individuals who complete a four year degree. 51% of our sample is classified as dependent. Dependency

[12]According to Department of Education data, the average time to complete a four year degree was six years and four months in the 2007-08 school year. In 2008 the six year completion rate at four year institutions was approximately 60 percent.

[13]Entry into borrowing typically occurs in students' first year. We allow borrowers to be in school for up to eight years after initial entry. That is, if borrowers are enrolled and borrowing for more than eight years, they are dropped from the sample.

status is defined by observable variables such as the student's age or past military status. Family income is on average, $55,000 per year, ranging up to roughly $200,000 per year.

III. The Effect of Student Debt on Graduate Education

A. OLS Results

We first measure the relation between post-graduate enrollment and undergraduate debt by estimating the following cross-sectional regression:

$$Postgraduate_i = \beta Debt_i + X_i'\alpha + \gamma_{j(i),c(i)} + u_i, \tag{1}$$

where $Postgraduate_i$ is an indicator of whether student i is enrolled in a postgraduate degree eight years after graduating from her undergraduate degree, $Debt_i$ is the total debt of student i after the final year of undergraduate studies, X_i are student-level controls, and $\gamma_{j(i),c(i)}$ are graduation cohort c by school j fixed effects. X_i includes indicator variables for female individuals, for individuals with children, and for individuals who obtained an Associates degree.

Table II reports the results. There is a robust negative association between student debt and an individual's propensity to pursue a postgraduate degree. The results are statistically significant and economically important. The coefficient in column 2, which includes school and cohort fixed effects, indicates that a $10,000 higher student debt is associated with a reduction of three percentage points in the probability of attending graduate school, corresponding to a 25% reduction in the unconditional probability (relative to a baseline of 12%). The coefficient on $Debt_i$ remains negative and significant when we include school by cohort fixed effects (in columns 3 and 4) as well as student-level controls (columns 2 and 4). Overall, the results are consistent with the notion that student debt deters investments in human capital.

Table III breaks down the results shown in the last column of Table II by school type. The first three columns break down the results by the institution control type, for-profit, public and private and the last three columns break down the results by selectivity.[14] The results by institutional control type indicate that the results are largely driven by public and private non-profits. The effect of debt on graduate enrollment is insignificant for for-profit schools. This is intuitive, as for-profits tend to enroll students with lower academic achievements, and they may be less likely to have the academic qualifications to pursue graduate studies. We see similar effects by institutional selectivity. The effects are larger for moderately selective institutions in comparison to selective institutions, and the effects are strongest for the most selective institutions.

Selective schools tend to be more expensive and charge higher tuition than non-selective institutions (Hoxby (2009)) and students at selective schools may be constrained by large tuition payments and debt burdens. The fact the students at the most selective schools show the largest enrollment effects is consistent with a credit constraints channel (see further discussion in Section IV), and may have important welfare implications. If high ability students are unable to make investments in human capital due to borrowing constraints, there could be large welfare losses as the returns tend to be might for students high high academic achievement (Avery and Turner (2012)).

The rich set of fixed effects that we include in specification (1) absorbs time-invariant unobservable factors such as school quality and cohort-specific variation in economic conditions that may drive the relation between student debt and graduate studies (e.g., cohorts that study in different stages of the business cycle). However, the negative association between the probability of enrolling in a graduate degree and student debt may be driven by time-varying student-specific heterogeneity that is unobservable to the econometrician. For example, family income affects educational attainment (Hoxby (1988)) and students with

[14]Selectivity is determined by Barron's. The lowest category is non-selective schools, competitive and very competitive are in the second group and highly competitive and most competitive schools are in the final group. Barron's classifies schools primarily based on the fraction of students admitted.

more debt could come from lower income families who are anyways less likely to attend graduate school (a negative omitted variable bias). Alternatively, students with higher expected incomes are more likely to attend graduate school and to take on more debt (a positive omitted variable bias). In the next section we address these concerns through an instrumental variables strategy.

B. Identification Strategy

School-level tuition changes are one of the most important determinants of the rise in the level of student debt (Baum (2015), Looney and Yannelis (2015a)).[15] We exploit the heterogeneous effects of large, school-level changes in tuition across students in different years of their degree. Intuitively, a large tuition increase after a student's freshman year would increase her borrowing requirements by more than the same tuition increase after her sophomore year, and by more than the same tuition increase after her junior year. We therefore use the variation in the propensity to borrow following a large school-level tuition change that is induced by student's academic within-degree "grade", which we here denote as cohort (e.g., cohort 1 corresponds to all students who just finished their first year at the time of a tuition increase), as an instrument for the level of undergraduate debt.[16] The identification assumption is that any difference in the probability of enrolling in graduate school for students in different cohorts at the time of a large tuition increase is only driven by differences in the level of undergraduate debt across these cohorts. We show evidence consistent with this assumption below.

Formally, we estimate the causal effect of student debt on the propensity to enroll in a post-graduate degree using the following two-stage least squares regression:

[15] In the Internet Appendix Figure A.1 we confirm this correlation graphically by plotting average debt at graduation relative to tuition changes in $1,000 bins for all students in our sample.

[16] A student's cohort at the time of a tuition increase is determined by the student's academic level in that school in their entry year.

$$(First\ Stage)\ Debt_i = \sum_{c=1}^{5} \pi_c \Delta Tuition_{j(i),t(i)} \times \delta_{j(i),t(i)}^{c(i)} + X_i'\omega_1 + \gamma_{j(i),t(i)} + \delta_{year(i)} + \eta_i, \quad (2)$$

$$(Second\ Stage)\ Postgraduate_i = \alpha + \beta \hat{Debt}_i + X_i'\lambda_1 + \gamma_{j(i),t(i)} + \delta_{year(i)} + \epsilon_i, \quad (3)$$

where $\Delta Tuition_{j(i),t(i)}$ is large tuition change for students in college j in year t (as the change in yearly tuition for year t relative to year $t-1$) for changes larger than 50% relative to the previous tuition level and zero otherwise, $\delta_{j(i),t(i)}^{c(i)}$ are cohort dummies that equal 1 for all students who finished their year c at school j in year $t-1$, and $\gamma_{j(i),t(i)}$ are year of tuition change t by school j fixed effects.[17] We control non-parametrically for differences in the characteristics of students across cohorts by limiting the comparison group to the eight previous cohorts before the tuition increase. Moreover, we include sample-wide cohort dummies $\delta_{year(i)}$ which absorb any underlying trends that affect all students in our sample. The instrumental variables correspond to the interactions of the change in tuition $\Delta Tuition_{j(i),t(i)}$ multiplied with the cohort dummies, π_c. This non-parametric specification gives the most flexibility in estimating the relation between debt and tuition changes across grades.[18] We expect the first stage coefficients π_c to be *decreasing* in c (i.e., $\pi_1 > \pi_2 > \pi_3 \ldots$), the reduced form coefficients–linking the average differences in $Postgraduate_i$ across cohorts–to be *increasing* in c, and the second stage coefficient β to be positive.

In our data, a student's school is measured in their final undergraduate year. Because many students transfer after their first year and because transfers are not observable in our

[17]For the small number of students exposed to more than one large tuition increase, we use the last one. As a robustness test, we report results of a regression that uses the same specification but with 25% tuition changes. See Section (D).

[18]In the Internet Appendix Table A.III we restrict the relationship between tuition increase across grades and debt to be linear and use this to estimate a similar 2SLS model.

data, this induces error in the measurement of students in first-year cohorts at the time of a tuition increase. To address this measurement error, we also estimate a grouped version of the first stage regression:

$$(First\ \ Stage)\ \ Debt_i = \sum_{g=1}^{2} \pi_c \Delta Tuition^{g(i)}_{j(i),t(i)} \times \delta^{g(i)}_{j(i),t(i)} + X_i'\omega_1 + \gamma_{j(i),t(i)} + \delta_{year(i)} + \eta_i, \quad (4)$$

where g indicates a group of cohorts. Specifically, we include cohorts one and two in group one ($g = 1$), cohorts three and four in group two ($g = 2$), and cohorts five through eight in the omitted category.

C. Results

The coefficients obtained from estimating the first stage in our sample are reported in Table 2. In Column 1 we first show as a baseline the relationship between tuition increase and debt. The coefficient implies that a \$1,000 increase in tuition leads to \$70 higher debt on average, across all individuals in our sample.[19] Columns 2 and 3 present the key feature of our identification strategy: the exposure to the tuition change depends on the student's cohort. For example, in column 3 we see that a \$1,000 tuition increase leads to \$150-\$180 higher debt for students in cohorts one and two relative to students in cohorts size, seven, and eight (the omitted category). Panel A in Figure 2 shows the first stage coefficients for the interactions of student cohort with tuition change (the $\pi_c \times \Delta Tuition_{j(i),t(i)}$ in regression (2)), which represent the differential level of debt for students attending the same undergraduate school in different grades during the year of a large tuition increase.

Consistent with the intuition behind our identification strategy, the figure highlights a negative monotonic relation between the academic grade at the time of a large tuition increase

[19]Note that all our results use headline tuition as defined by each university and not the actual tuition paid by students, which is likely to be correlated with other determinants of debt and enrollment in graduate school.

and the level of undergraduate debt, in particular for cohorts two and higher. The observed positive change between cohorts one and two is likely due to a measurement error: we only observe students' graduation school, and students are most likely to transfer to another school after the first year. Hence, some students who are labeled as facing a tuition increase in their first year would in effect face less years of high tuition, which reduces the power of the instrument. In order to mitigate the effect of this measurement error, we estimate the grouped-cohort specification (4). Columns 4 and 5 in Table IV and Panel B in Figure 2 show the estimates, which confirm the monotonic effect of tuition increases on the level of student debt across all grouped cohorts. For example, in column 5 we see that a \$1,000 tuition increase leads to \$170 higher debt for students in group one (cohorts one and two) relative to students in group three (cohorts 5-8, the omitted category).[20]

Our identification assumption implies that in the absence of a large tuition increase, students attending different cohorts in the same school at the time of a large tuition increase would have had similar probabilities of enrolling in graduate school. To support the validity of this assumption, we estimate the first stage specification (2) replacing the left hand side variable *Debt* with student characteristics observable at the time of entering an undergraduate degree, such that family income, gender, number of children, and having an associate degree. An absence of a monotonic relation between these predetermined student characteristics and the exposure to large tuition increases would provide support for the identification assumption. Indeed, the results reported in Table V show that these predetermined student characteristics do not exhibit a monotonic relation, or any relationship at all, supporting the validity of our identification assumption.

We have shown that students who have just completed earlier grades at the time of a tuition increase end up with relatively higher levels of student debt once they obtain their

[20]We report the F-statistic of the test that all coefficients in the first-stage regression are statistically different from zero in the last row of Table IV, although the power of the set of instruments cannot be inferred directly from this test. Indeed, we identify from the pattern of differences in debt across cohorts rather than on pure significance of the coefficients.

undergraduate degree. Does a higher level of student debt lead to changes in the probability of enrolling in graduate school? We first report the reduced form coefficients in Figure 3 (all estimates are reported in Table A.I). The coefficients plotted in Panel A show the average differential probability of enrolling in graduate school for students attending different cohorts of the same school at the time of a large tuition increase. As expected, the figure shows a positive and monotonic relation between a student's grade at the time of a tuition increase and the probability of attending graduate school. The difference between cohorts one and two is small and, again, likely to be contaminated by measurement error due to the fact that students transfer after their first year. To address this concern, Panel B presents the reduced form coefficients for the grouped cohorts specification, which do show a monotonic relation throughout.

The estimates of the second stage regression (3) are reported in Table VI. The results in columns 1 and 2 correspond to the baseline regression using all cohorts separately (regression (2)) and the results in columns 3 and 4 correspond to the grouped first stage regression (4). The coefficients reveal a robust negative effect of student debt on the probability of attending graduate school: a \$10,000 increase in student debt causes a 4% to 6% reduction in the probability of attending graduate school in the next eight years. The estimated magnitude is larger in magnitude than the estimates in the OLS specifications, suggesting a positive bias in the OLS specification.

To get a sense of the magnitude of this effect, note that \$4,000 in higher debt, which corresponds to 34% of a standard deviation of this variable in our sample, causes a 1.6 to 2.4 percentage points reduction in the probability of attending graduate school in the next eight years (a 15-20% drop relative to a 12% mean). The effect is also large relative to other factors that drive the probability of attending graduate school. For instance, women have a one percentage point higher probability of attending graduate school than men and having a child is associated with two percentage points lower probability of attending graduate school.

To further support the validity of our identification strategy, we report the estimates of second stage regressions where we replace *Postgraduate* with predetermined student characteristics. The results are reported in the Internet Appendix Table A.III. We find no effects of student debt on family income, gender, the number of children, and likelihood of having an associates degree. The results confirm that the difference in probability of attending graduate school for students in early versus late grade cohorts at the time of a tuition increase are not driven by predetermined student characteristics.

Finally, we perform a version of Hausman test and compare estimates from OLS and IV specifications. Test results are reported in the last two rows of Table VI. We find that in all four specifications we cannot reject the null that the difference between OLS and IV estimates is zero, suggesting that OLS estimates are likely to be consistent. Thus, the result justifies OLS specification for more complicated models used in the remaining part of the paper.

D. Robustness

We perform several tests, reported in Table (VII), that underscore the robustness of our results. In columns 1 and 2 we run our main OLS specification with fixed effects (regression (1)) and include the duration of undergraduate studies as a control variable. This controls for concerns that undergraduate debt may be mechanically correlated with the duration of studies. The effect of duration on the propensity to enroll in a graduate degree is hard to sign and, at best, tenuous. For example, taking an extra year might allow some students to take additional classes and better prepare themselves for graduate school admissions. On the other hand, longer time to completion may be viewed as a negative signal by admissions committees. The effect of student debt on graduate studies is essentially unchanged, remaining negative and significant (and of a slightly larger magnitude).

Second, we augment the fixed effects regressions with state times cohort fixed effects.

We therefore shut down any variation that can be related to state-specific business cycles. The results remain qualitatively unchanged. In columns 5 and 6 the dependent variable is changed to an indicator of whether a borrower enrolls in graduate school within nine years of entering repayment (it is eight years in our main specification). The results are similar to the main specification and remain significant at the 1% level.[21] In the Internet Appendix Table (A.IV) we include the regression output when we change the definition of large tuition changes to 25%, rather than 50% as in our baseline specification. The main results hold, although the magnitude of the effect is larger.

IV. Heterogeneity and Mechanisms

In this section we conduct heterogeneity tests and investigate the mechanisms through which student debt may reduce the the probability of attending graduate school. We consider two non-mutually-exclusive mechanisms: the credit constraints mechanism and the under-investment/debt overhang mechanism.[22]

First, a higher level of student debt may increase the cost of debt financing or even lead to exclusion from credit markets. Graduate students who need to borrow to finance their education or other expenses while they study may thus be unable to do so. For instance, large student debt may cause an individual to hit the federal student borrowing lifetime limit, and therefore to finance her graduate school through private, more expensive (non-subsidized), lenders. A larger stock of student debt can also lead to more defaults (Yannelis (2016)), which may impair individual's access to credit and employment (Liberman (2016), Bos, Breza, and Liberman (2016)). This is the *credit constraints* channel.

Higher student debt may also lead to under-investment via the debt overhang channel

[21]We have also tried the main specification changing the dependent variable to an indicator of whether a borrower enrolls in graduate school within seven and nine years of entering repayment, and the results remain robust.

[22]We note that student debt may increase the probability of attending graduate school in order to postpone repayment of undergraduate student debt. This channel is inconsistent with the results.

(Myers (1977)). Under this hypothesis, students choose not to undertake positive NPV investments in human capital due to existence of a large stock of non-dischargeable debt, as only part of the benefits from the new project are available to the investor (the rest benefits the existing creditor). This is the *under-investment* channel.[23]

We start by exploring the role of family income in the relation between student debt and postgraduate studies. Table VIII reports estimates of equation (1), the most saturated version of the fixed effects OLS specification, by each family income quintiles, and Figure 4 plots the coefficients. We do not estimate the IV coefficient by quintile because the instrument has very little power among high income individuals. As usual, the dependent variable is an indicator of whether student i is enrolled in a postgraduate degree eight years after graduating from her undergraduate degree. The results reveal a negative and monotonic relationship between family income and the effect of student debt on the probability of attending graduate school. A \$10,000 increase in student debt is associated with a 3.7% reduction in the probability of attending graduate school for students from the lowest family income quintile and with a 0.05% reduction in the probability of attending graduate school for students from the fifth family income quintile. Thus, the association between student debt and the probability of attending graduate school for the highest family income quintile is close to zero, both economically and statistically.

This result suggests an unequal incidence of the effect of student debt on future education, with a stronger effect for students from low income backgrounds. However, this result does not allow us to distinguish between the credit constraints and the under-investment channels. Indeed, family income mitigates the role of external financing in the credit constraints channel, but it also reduces the incentive to under-invest because individuals are less likely to be close to bankruptcy.

[23]On the other hand, students may undertake risky negative NPV investments in human capital due to the existence of large, non-dischargeable debt. This may happen when the investor is able to shift negative cash-flows from the project to the existing creditor. Since our main results clearly suggest that higher level of student debt leads to lower investment in postgraduate degrees, we can rule out this *risk-shifting* channel.

We suggest three additional tests that allow us to differentiate between the two mechanisms. First, we consider increases in the federal student borrowing limit. Internet Appendix Figure A.2 shows the time series since 1970 of the median, 75th percentile and 95th percentile of student borrowing. In 1993 and 2007 federal borrowing limits were increased, alleviating borrowing constraints. The figure shows that borrowing increased sharply across the three plotted percentiles following increases in the borrowing limit. If binding credit constraints are driving the negative correlation between debt and graduate enrollment, then we expect our results to be attenuated in the years immediately after limit increases. That is because, at that time, individuals who want to attend graduate school have higher loan limits and are therefore less affected by credit constraints. We also expect this effect to gradually fade away as inflation in tuition and general goods erodes the real value of the limit increases. Columns 1 and 2 in Table IX report the results of our main tests interacting undergraduate debt with the two cohorts immediately following the limit increase. *Limit increase* is an indicator of the two years following an increase in the federal student borrowing limit. We find that federal student borrowing limit increases are associated with a weaker relation between the level of student debt and the probability of attending graduate school. Here we also focus on the OLS specification saturated with fixed effects. In the Internet Appendix Table (VII) we show the IV results for this heterogeneity test, which show the same pattern although the estimates are less precise. Overall, this result supports the credit constraint channel.

Next, we use the 1998 change in federal rules concerning the treatment of student debt in personal bankruptcy. Specifically, after 1998 federal student loans became non-dischargeable in bankruptcy. Prior to 1998, student loans were dischargeable after seven years in repayment.[24] If the under-investment channel holds, the law change is expected to enhance the negative relation between debt and graduate enrollment. This is because bankruptcy does not eliminate the impact on student debt on profits from future investments. Columns

[24]See Yannelis (2016) for a discussion of student loan bankruptcy.

3 and 4 in Table IX report results interacting undergraduate debt with $Non\,Dischargeable$, which is one when student debt is fully non-dischargeable upon bankruptcy. We find that the law change is not associated with significant changes in the relation between the level of student debt and the probability of attending graduate school. Therefore, this result does not support the under-investment channel and our results appear consistent with the credit constraints channel.

Last, we consider the role of financial education. Recent studies have shown that financial literacy has significant impacts on the debt behavior of young borrowers (e.g., Lusardi, Mitchell, and Curto (2010); Brown, Grigsby, van der Klaauw, Wen, and Zafar (2016)). Students who take personal finance courses are less likely to be financially constrained for a number of reasons. First, borrowers with higher levels of financial education are more likely to be aware of alternative sources of borrowing, such as private student loans or home equity loans. Second, borrowers who took personal finance courses are more likely to avoid high interest debt such as credit card debt, which can negatively impact credit scores. Third, borrowers with financial education better understand credit scores and the implications on future borrowing, and thus are more likely to have access to credit. Finally, borrowers who took financial education course are less likely to default (Brown, Grigsby, van der Klaauw, Wen, and Zafar (2016)), and thus are likely to have higher credit scores. Therefore, the credit constraints channel predicts a weaker relation between debt and graduate enrollment for financially educated students.[25]

To perform this test we use data from Brown, Collins, Schmeiser, and Urban (2014) on state personal finance mandates for high school graduation to study the interaction between the impact of debt on graduate enrollment, and financial education. Columns 5 and 6 in Table IX report the results of our main regression where we interact undergraduate tuition with an indicator of whether an individual was required to take a personal finance

[25]One possibility is that individuals in states with mandatory financial education are less likely to increase their debt following tuition increases. We test our first stage and find no differential effect of the first stage coefficients among stages that require financial education.

course in the year that they graduate high school.[26] The results indicate that the effect of undergraduate debt on graduate enrollment is strongly attenuated for borrowers who were required to take a financial education course. This is consistent with the earlier evidence that credit constraints impact graduate enrollment, and that undergraduate debt affects graduate enrollment through a credit constraints channel.

To summarize, the results on borrowing limit increases, treatment of student debt in defaults, and financial education strongly support the credit constraints channel. We thus conclude that our baseline results are best explained by this mechanism.

V. Conclusion

In this paper we document that increased student debt causes individuals to forgo graduate school. Our results suggest that this effect arises because student debt exacerbates credit constraints, which restrict individuals' choice set in terms of feasible investments in human capital. The results are unequally distributed and affect lower income students disproportionately more. Moreover, more financial education and increases to the federal loan limit seem to alleviate these credit constraints.

Our results have two important implications. First, our results suggest policymakers and academics should recognize that the choice of financing of investments in human capital with debt is not innocuous, and may reduce the total level of human capital relative to alternatives that do not tighten credit constraints. Second, our results speak to an unintended consequence of the fast and large increase in student debt in the U.S. during the past 10 years. Indeed, in the Internet Appendix Figure A.3 we plot the evolution of undergraduate student debt and the number of graduate students. While we do not intend

[26]State of residence is obtained from the last FAFSA form that that student filed. We assume that the state lived in this state at age 18, and the indicator measured whether students were required to take a person finance course in the state of residence at 18 using data from Brown, Collins, Schmeiser, and Urban (2014). The list of states and the year in which the requirement was enacted are presented in the Internet Appendix Table A.V.

to explain the entire time-series variation in graduate enrollment, the change in the slope of the level of debt post 2009–a very fast increase– and the flattening slope in graduate enrollment are consistent with our main result, as there is also a faster increase in student debt after 2008. While this increase in debt may have important future consumption effects, the effects that we document on investments in education may have first order implications in reducing the future supply of highly educated individuals to areas such as research and development and health. Future work should address the aggregate implications of increased student loan debt.

References

Albuquerque, Rui, and Hugo A. Hopenhayn, 2004, Optimal lending contracts and firm dynamics, *The Review of Economic Studies* 71, 285–315.

Avery, Christopher, and Sarah Turner, 2012, Student loans: Do college students borrow too much–or not enough?, *Journal of Economic Perspectives* 26, 165–92.

Baum, Sandy, 2015, The evolution of student debt in the united states, in Brad Hershbein, and Kevin M. Hollenbeck, ed.: *Student Loans and the Dynamics of Debt* . pp. 11–36 (WE Upjohn Institute).

Bos, Marieke, Emily Breza, and Andres Liberman, 2016, The labor market effects of credit market information, Working Paper 22436 National Bureau of Economic Research.

Brown, Alexandra M, J Michael Collins, Maximilian D Schmeiser, and Carly Urban, 2014, State mandated financial education and the credit behavior of young adults, *Divisions of Research & Statistics and Monetary Affairs Federal Reserve Board, Washington, DC, Finance and Economics Discussion Series*.

Brown, Meta, John Grigsby, Wilbert van der Klaauw, Jaya Wen, and Basit Zafar, 2016, Financial education and the debt behavior of the young, *Review of Financial Studies* p. hhw006.

Carneiro, Pedro, James J Heckman, and Edward J Vytlacil, 2011, Estimating marginal returns to education, *The American economic review* 101, 2754–2781.

Cooper, Daniel, and Christina J. Wang, 2014, Student loan debt and economic outcomes, *Federal Reserve Bank of Boston Working Paper*.

Cordoba, Juan Carlos, and Marla Ripoll, 2013, What explains schooling differences across countries?, *Journal of Monetary Economics* 60, 184 – 202.

Cox, Natalie, 2016, Pricing, selection, and welfare in the student loan market: Evidence from borrower repayment decisions", *Mimeo*.

Dobbie, W., P. Goldsmith-Pinkham, N. Mahoney, and J. Song, 2016, Bad credit, no problem? credit and labor market consequences of bad credit reports, *Working Paper*.

Galor, Oded, and Omer Moav, 2004, From physical to human capital accumulation: Inequality and the process of development, *The Review of Economic Studies* 71, 1001–1026.

Gicheva, Dora, et al., 2011, Does the student-loan burden weigh into the decision to start a family, *Working paper*.

Goldin, Claudia, and Lawrence F. Katz, 2008, *The Race between Education and Technology* (Belknap of Harvard UP).

Hoxby, Caroline, 1988, How much does school spending depend on family income? the historical origins of the current school finance dilemma, *American Economic Review* 88, 309–314.

——— , 2009, The changing selectivity of american colleges, *Journal of Economic Perspectives* 23, 95–118.

Ji, Yan, 2016, Job search under debt: Aggregate implications of student loans, *Mimeo*.

Lee, Donghoon, Wilbert Van der Klaauw, Andrew Haughwout, Meta Brown, and Joelle Scally, 2014, Measuring student debt and its performance, *FRB of New York Staff Report*.

Liberman, Andres, 2016, The value of a good credit reputation: Evidence from credit card renegotiations, *Journal of Financial Economics* 120, 644–660.

Lochner, Lance, and Alexander Monge-Naranjo, 2015, Student loans and repayment: Theory, evidence and policy, Working Paper 20849 National Bureau of Economic Research.

Lochner, Lance J., and Alexander Monge-Naranjo, 2011, The nature of credit constraints and human capital, *American Economic Review* 101, 2487–2529.

Looney, Adam, and Constantine Yannelis, 2015a, A crisis in student loans? how changes in the characteristics of borrowers and in the institutions they attended contributed to rising loan defaults, *Brookings Papers on Economic Activity*.

——— , 2015b, Is high student loan debt always a problem?, *SIEPR Policy Brief*.

Lusardi, Annamaria, Olivia S Mitchell, and Vilsa Curto, 2010, Financial literacy among the young, *Journal of Consumer Affairs* 44, 358–380.

Mezza, Alvaro A., Daniel R. Ringo, Shane M. Sherlund, and Kamila Sommer, 2016, On the effect of student loans on access to homeownership, *Federal Reserve Board Finance and Economics Discussion Series*.

Mullainathan, Sendhil, and Eldar Shafir, 2013, *Scarcity: Why having too little means so much* (Macmillan).

Myers, Stewart C, 1977, Determinants of corporate borrowing, *Journal of Financial Economics* 5, 147–175.

Palacios, Miguel, 2014, Human capital as an asset class implications from a general equilibrium model, *The Review of Financial Studies* 28, 978–1023.

Rothstein, Jesse, and Cecilia Elena Rouse, 2011, Constrained after college: Student loans and early-career occupational choices, *Journal of Public Economics* 95, 149–163.

Scott-Clayton, Judith, and Basit Zafar, 2016, Financial aid, debt management, and socioeconomic outcomes: Post-college effects of merit-based aid, Working Paper 22574 National Bureau of Economic Research.

Sun, Stephen Teng, and Constantine Yannelis, 2013, Credit constraints and demand for higher education: Evidence from financial deregulation, *Review of Economics and Statistics*.

Whited, Toni M, 1992, Debt, liquidity constraints, and corporate investment: Evidence from panel data, *The Journal of Finance* 47, 1425–1460.

Yannelis, Constantine, 2016, Strategic default on student loans, *Working Paper*.

Figure 1: Number of large tuition changes by year

This figure shows the number of large tuition changes in our sample (tuition changes by more than 50% relative to previous year) by repayment cohort.

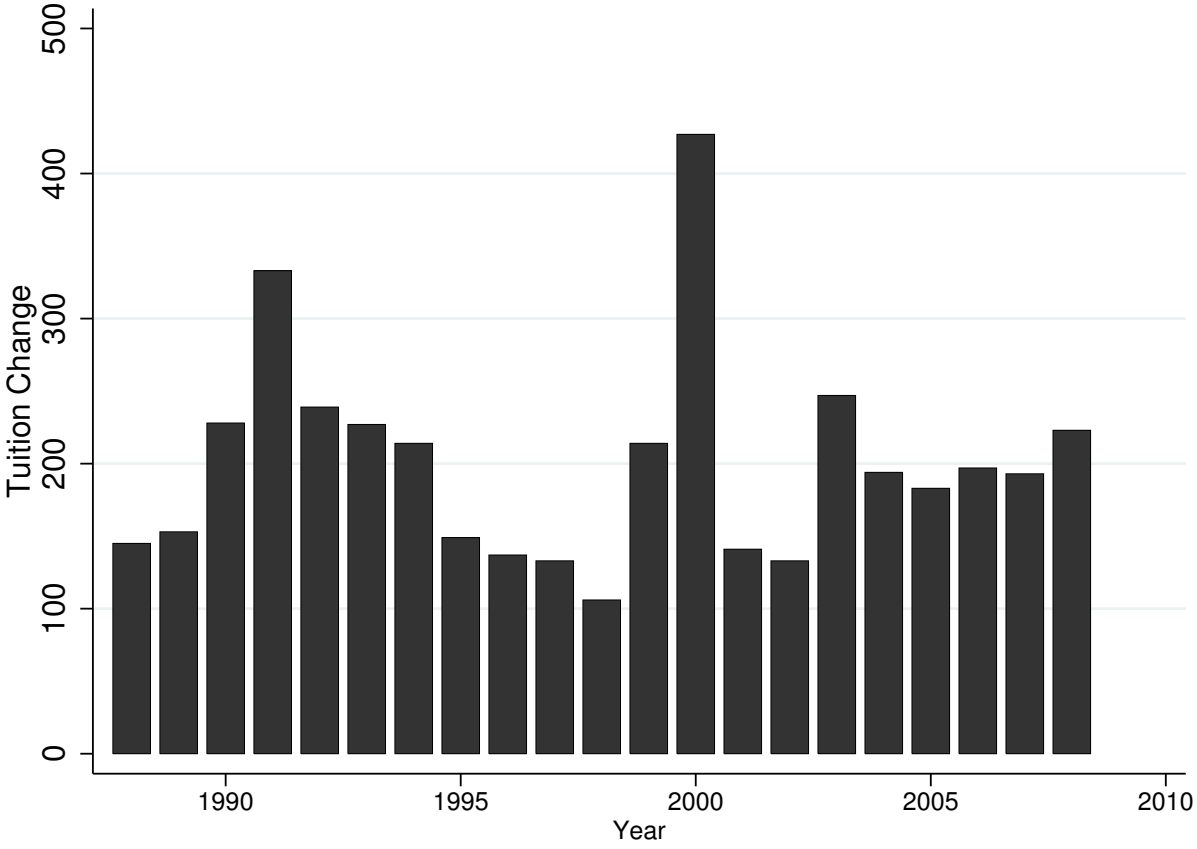
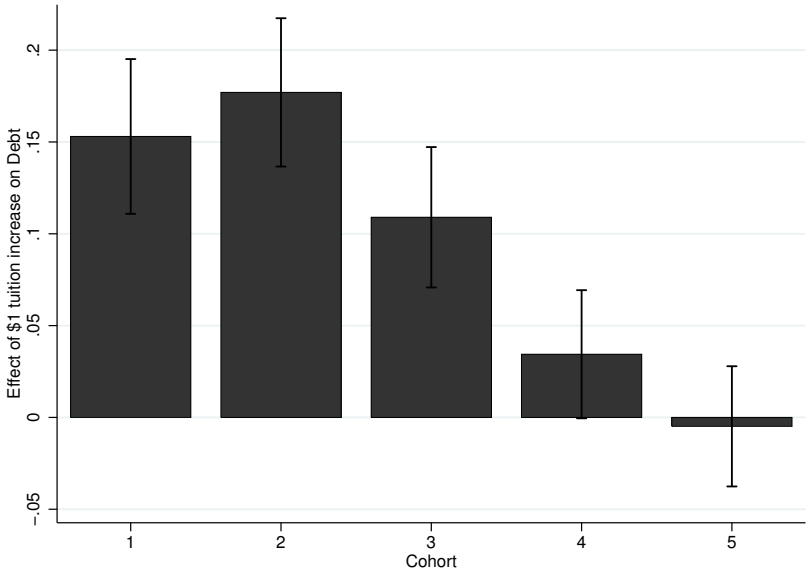
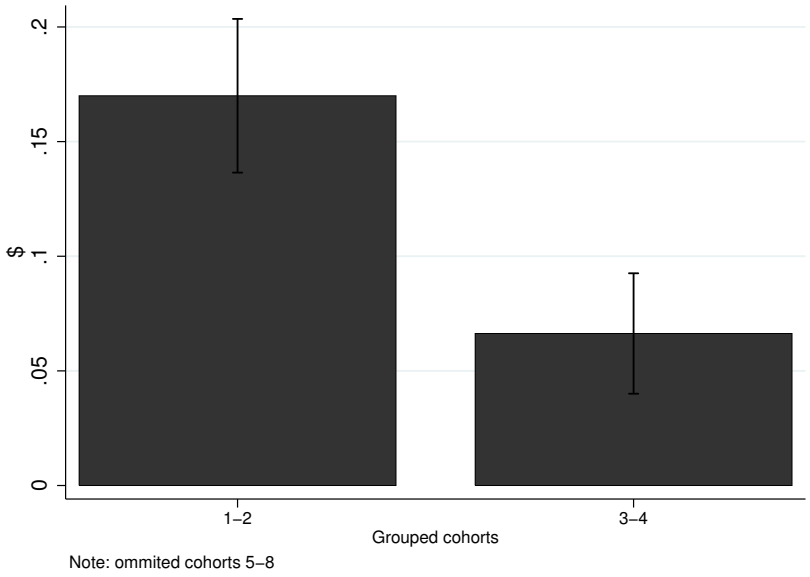


Figure 2: First stage estimates

This figure shows the effect of $1 increase in tuition on the level of total undergraduate debt among students in different cohorts at the time of a large tuition increase in the same school. In panel A, bars plot π_c coefficients of the first stage regression (2). Vertical lines plot 95% confidence intervals. In panel B, bars plot estimates from grouped first stage specification (4).



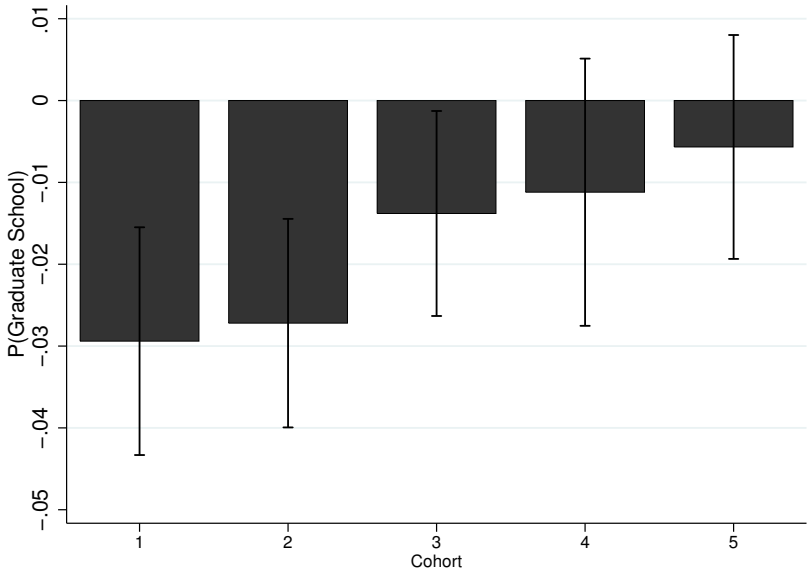
Panel A: Basic specification



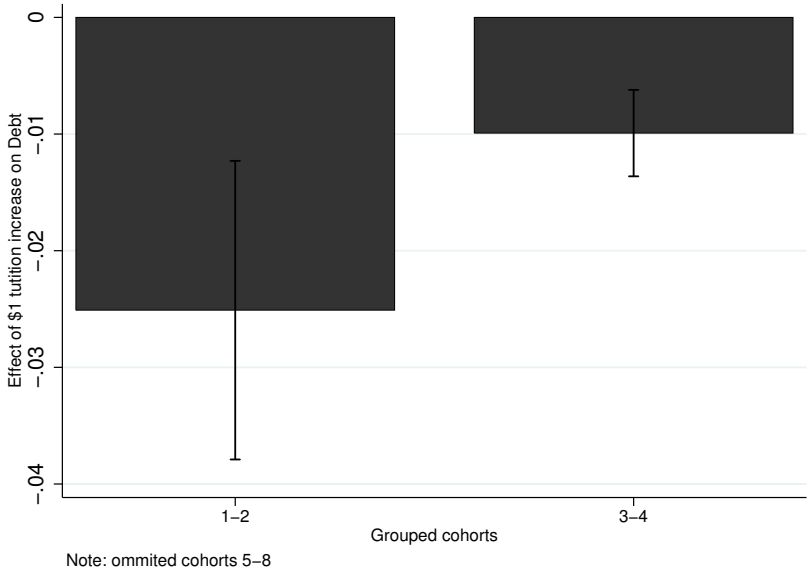
Panel B: Grouped specification

Figure 3: Reduced form estimates

Panel A plots estimated coefficients π_c from the following specification: $Postgraduate_i = \sum_{c=1}^{5} \pi_c \Delta Tuition_{j(i),t(i)} \times \delta^{c(i)}_{j(i),t(i)} + X_i'\omega_1 + \gamma_{j(i),t(i)} + \delta_{year(i)} + \eta_i$. The coefficients show the effect of \$1 increase in tuition on the level of total undergraduate debt among students in cohort c at the time of a large tuition increase in the same school. Vertical lines plot 95% confidence intervals. In panel B, bars plot reduced form estimates from the grouped cohort specification.



Panel A: Basic specification



Panel B: Grouped specification

Figure 4: Student debt and graduate studies: the role of family income

This figure plots estimated coefficients β of equation (1) for five family income quintiles. The coefficients show the effect of \$10,000 increase in student debt on the probability of being enrolled in a postgraduate degree within eight years after graduating from undergraduate degree. Regressions include graduation cohort by school fixed effect and student-level control variables. Vertical lines plot 5% confidence intervals.

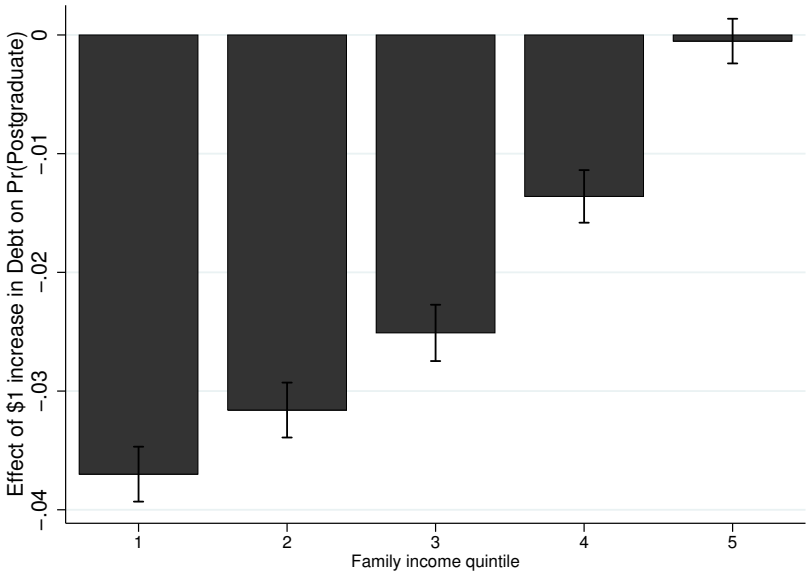


Table I: Summary statistics

This table shows the mean, standard deviation, median, minimum, and maximum of all variables. Note that large tuition increase is measuring conditional on being non-zero. All dollar values are in 2014 dollars. Income, borrowing and tuition have been winsorized at the 99% level. All variables are defined in Section II.

	Mean	SD	Min	Max
Postgraduate	0.1213	0.3265	0	1
Debt ($ 10,000)	1.856	1.193	0.000	7.839
Female	0.4129	0.4923	0	1
Children	0.2411	0.6571	0	9
Associate Degree	0.0471	0.2119	0	1
Dependent	0.5113	0.4999	0	1
Family income ($)	54,985.1	54,108.3	0	209,220
Entry tuition ($)	10,179.1	8,485.5	0	64,693
Exit tuition ($)	11,479.5	9,402.5	0	64,693
Large tuition increase ($)	9,323.7	7,520.5	141	29,088
Limit increase	0.3388	0.4733	0	1

Table II: Student debt and probability of attending postgraduate school: OLS estimates

This table reports estimates of equation (1). The dependent variable in each specification is an indicator of whether individual i enrolled in graduate school within eight years of entering into borrowing. $Debt_i$ is the total debt of student i in the final year of undergraduate studies measured in \$10,000. Regressions in columns 1 and 2 include graduation cohort and school fixed effects; in columns 3 and 4 regressions include graduation cohort by school fixed effects. In column 2 and 4 regressions include student-level control variables. The inclusion of fixed effects is denoted beneath each column. The sample is restricted to individuals who complete a 4 year degree. All data comes from a 4% sample of the NSLDS. Standard errors (in parentheses) are clustered at the school level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

Dependent variable: *Postgraduate*				
	(1)	(2)	(3)	(4)
Debt	-0.0084***	-0.0304***	-0.0335***	-0.0316***
	(0.0005)	(0.0005)	(0.0005)	(0.0005)
Female		-0.0041***		-0.0024*
		(0.0012)		(0.0013)
Children		-0.0247***		-0.0259***
		(0.0009)		(0.0010)
Associate degree		-0.0502***		-0.0553***
		(0.0027)		(0.0029)
R^2	0.143	0.294	0.339	0.356
Obs.	265,006	265,006	265,006	265,006
Fixed effects				
School	Yes	Yes		
Cohort	Yes	Yes		
School×Cohort			Yes	Yes

Table III: Student debt and probability of attending postgraduate school: OLS estimates by school type

This table breaks down the results shown in the last column of Table II by school type. The first three columns break down the results by the institution control type, for-profit, public and private and the last three columns break down the results by selectivity. Selectivity is determined by Barron's. The lowest category is non-selective schools, competitive and very competitive are in the second group and highly competitive and most competitive schools are in the final group. Barron's classifies schools primarily based on the fraction of students admitted. Standard errors (in parentheses) are clustered at the school level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

Dependent variable: *Postgraduate*						
School type	For-profit	Public	Private	Non-selective	Competitive	Highly competitive
	(1)	(2)	(3)	(4)	(5)	(6)
Debt	0.0017	-0.0312***	-0.0404***	0.0016	-0.0272***	-0.0452***
	(0.0010)	(0.0007)	(0.0009)	(0.0010)	(0.0007)	(0.0009)
R^2	0.352	0.277	0.474	0.359	0.340	0.419
Obs.	29,456	141,427	94,123	32,545	140,386	92,075
Fixed effects						
School	Yes	Yes	Yes	Yes	Yes	Yes
Cohort	Yes	Yes	Yes	Yes	Yes	Yes

Table IV: First stage results: the differential effect of tuition increases on student debt across cohorts

This table reports estimates of first stage regressions. Column 1 shows the relationship between tuition increase and student debt. Columns 2 and 3 show the differential effect of tuition increases on different cohorts. Columns 4 and 5 show the effect of tuition increases on different groups of cohorts. All regressions include year of tuition change by school fixed effects, where the dummy for year of tuition change equals one for individuals who are enrolled at the institution of their undergraduate degree between one and eight years before the tuition increase. Heteroskedasticity-robust standard errors (in parentheses) are clustered at school-year level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

Dependent variable: *Debt*	(1)	(2)	(3)	(4)	(5)
$\Delta Tuition$	0.0722***				
	(0.0082)				
$\Delta Tuition \times \delta^{c=1}$		0.151***	0.153***		
		(0.0213)	(0.0215)		
$\Delta Tuition \times \delta^{c=2}$		0.186***	0.177***		
		(0.0204)	(0.0206)		
$\Delta Tuition \times \delta^{c=3}$		0.109***	0.109***		
		(0.0196)	(0.0195)		
$\Delta Tuition \times \delta^{c=4}$		0.0376**	0.0344*		
		(0.0178)	(0.0178)		
$\Delta Tuition \times \delta^{c=5}$		-0.00288	-0.00486		
		(0.0166)	(0.0167)		
$\Delta Tuition \times \delta^{g=1}$				0.174***	0.170***
				(0.0171)	(0.0171)
$\Delta Tuition \times \delta^{g=2}$				0.0677***	0.0663***
				(0.0134)	(0.0134)
Controls	No	No	Yes	No	Yes
R^2	0.021	0.204	0.226	0.204	0.226
Obs.	265,006	265,006	265,006	265,006	265,006
F-Test		23.02	22.40	51.79	49.53

Table V: Tuition increases and student characteristics: placebo test

This table reports estimates of first stage regression (2), where *Debt* is replace with student characteristics, such that family income, gender, number of children, and having an associate degree. All regressions include year of tuition change by school fixed effects. Heteroskedasticity-robust standard errors (in parentheses) are clustered at school-year level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

Dependent variable:	Family income (1)	Female (2)	Children (3)	Associate degree (4)
$\Delta Tuition \times \delta^{c=1}$	1268.6*	-0.00238	-0.0000	0.00485
	(695.8)	(0.00793)	(0.0109)	(0.0045)
$\Delta Tuition \times \delta^{c=2}$	-1268.0**	0.0137*	0.0159	0.0169***
	(565.2)	(0.00702)	(0.0102)	(0.0042)
$\Delta Tuition \times \delta^{c=3}$	-1102.1*	0.00920	-0.0217**	0.0085
	(638.7)	(0.00675)	(0.00965)	(0.0038)
$\Delta Tuition \times \delta^{c=4}$	-1161.7**	0.00248	-0.000676	0.0022
	(534.5)	(0.00566)	(0.00926)	(0.0026)
$\Delta Tuition \times \delta^{c=5}$	-905.1*	0.00613	-0.00811	-0.0008
	(487.9)	(0.00659)	(0.00880)	(0.0029)
R^2	0.1230	0.1868	0.0492	0.2092
Obs.	265,006	265,006	265,006	265,006

Table VI: The effects of student debt on graduate studies

This table reports estimates of second stage regression (3). First stage results are reported in Table IV. All regressions include year of tuition change by school fixed effects. Heteroskedasticity-robust standard errors (in parentheses) are clustered at school-year level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

Dependent variable: *Postgraduate*	(1)	(2)	(3)	(4)
Debt	-0.0488**	-0.0385**	-0.0613**	-0.0497*
	(0.0179)	(0.0184)	(0.0276)	(0.0280)
Controls	No	Yes	No	Yes
First stage	Cohorts	Cohorts	Groups	Groups
Obs.	265,006	265,006	265,006	265,006
Hausman test statistic	1.09	0.28	0.07	0.03
Hausman test p-value	0.597	0.296	0.863	0.791

Table VII: Student debt and graduate studies: robustness

This table reports estimates of our main FE specification. The dependent variable is an indicator of whether student i is enrolled in a postgraduate degree eight years after graduating from her undergraduate degree. $Debt_i$ is the total debt of student i in the final year of undergraduate studies. In columns 1 and 2, duration is included. In columns 3 and 4 the regressions include state times cohort fixed effects. Columns (5) and (6) change the dependent variable to an indicator of whether a borrower enrolls in graduate school within nine years of entering repayment. All columns include graduation cohort by school fixed effects and student-level control variables. Heteroskedasticity-robust standard errors (in parentheses) are clustered at school-year level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

Dependent variable: *Postgraduate*						
	(1)	(2)	(3)	(4)	(5)	(6)
Debt	-0.0637***	-0.0756***	-0.0360***	-0.0340***	-0.0335***	-0.0316***
	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
Controls	No	Yes	No	Yes	No	Yes
School×cohort FE	Yes	Yes	Yes	Yes	Yes	Yes
State×cohort FE	No	No	Yes	Yes	No	No
Obs.	265,006	265,006	265,006	265,006	265,006	265,006

Table VIII: Student debt and graduate studies: the role of family income

This table reports estimates of equation (1) for five family income quintiles. The dependent variable is an indicator of whether student i is enrolled in a postgraduate degree eight years after graduating from her undergraduate degree. $Debt_i$ is the total debt of student i in the final year of undergraduate studies. All columns include graduation cohort by school fixed effects and student-level control variables. Heteroskedasticity-robust standard errors (in parentheses) are clustered at school-year level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

Dependent variable: *Postgraduate*					
Income quintile:	First	Second	Third	Fourth	Fifth
Average income (2014 dollars):	\$3.0K	\$16.8K	\$38.6K	\$72.2K	\$144.3K
	(1)	(2)	(3)	(4)	(5)
Debt	-0.0370***	-0.0316***	-0.0251***	-0.0136***	-0.0005
	(0.0012)	(0.0012)	(0.0012)	(0.00113)	(0.0010)
Controls	Yes	Yes	Yes	Yes	Yes
School×cohort FE	Yes	Yes	Yes	Yes	Yes
R^2	0.199	0.167	0.183	0.183	0.139
Obs.	53,181	52,316	49,759	52,526	57,209

Table IX: Student debt and graduate studies: cross-sectional variation tests

This table reports estimates of equation (1). The dependent variable is an indicator of whether student i is enrolled in a postgraduate degree eight years after graduating from her undergraduate degree. $Debt_i$ is the total debt of student i in the final year of undergraduate studies. In columns 1 and 2, *Debt* is interacted with an indicator of the year following an increase the credit limit, *Limit increase*. In columns 3 and 4, *Debt* is interacted with *Non Dischareable*, which is one when student debt is fully non-dischargeable upon bankruptcy. In columns 5 and 6, *Debt* is interacted with *Financial Education*, which indicators whether a state requires students to complete a mandatory personal finance year to graduate high school, in the year a student is 18, as determined by their state of residence on from the FAFSA. The list of states is and the date in which the requirement was enacted are presented in Internet Apendix Table A.V). All columns include graduation cohort by school fixed effects and student-level control variables. Heteroskedasticity-robust standard errors (in parentheses) are clustered at school-year level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

Dependent variable: *Postgraduate*	(1)	(2)	(3)	(4)	(5)	(6)
Debt	-0.0336***	-0.0316***	-0.0431***	-0.0406***	-0.0341***	-0.0328***
	(0.0005)	(0.0005)	(0.0006)	(0.0006)	(0.0010)	(0.0010)
Debt $*$ *Limit increase*	0.0089***	0.0077***				
	(0.0012)	(0.00122)				
Debt $*$ *Non Dischargeable*			0.0008	-0.0018		
			(0.0083)	(0.0083)		
Debt $*$ *Financial Education*					0.0073***	0.0060***
					(0.0020)	(0.0060)
Controls	No	Yes	No	Yes	No	Yes
School×cohort FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.339	0.356	0.261	0.393	0.339	0.362
Obs.	265,006	265,006	265,006	265,006	265,006	265,006

Internet Appendix for

"Debt and Human Capital: Evidence from Student Loans,"

by Vyacheslav Fos, Andres Liberman, and Constantine Yannelis

Figure A.1: Relationship Between Tuition Changes and Borrowing

This figure shows total undergraduate debt at graduation in $1,000 bins of large tuition changes.

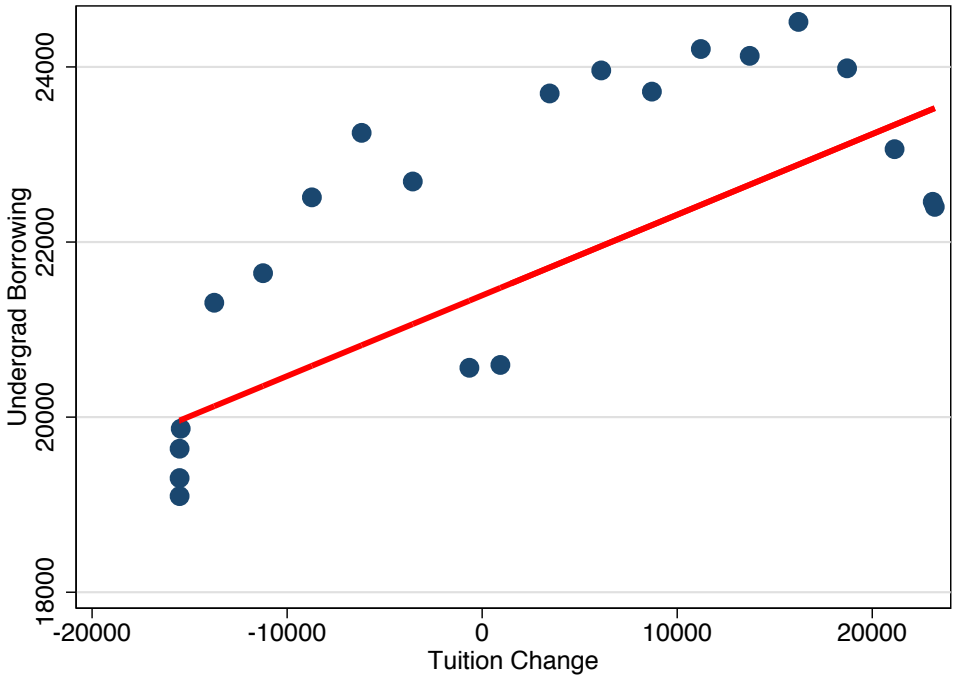


Figure A.2: Evolution of undergraduate student debt and credit limit increase

This figure shows undergraduate student borrowing by repayment year. In 1993 and 2007 federal borrowing limits were increased, alleviating borrowing constraints. The figure shows that, following increases in borrowing limits, borrowing increased sharply. Source is Looney and Yannelis (2015) data appendix.

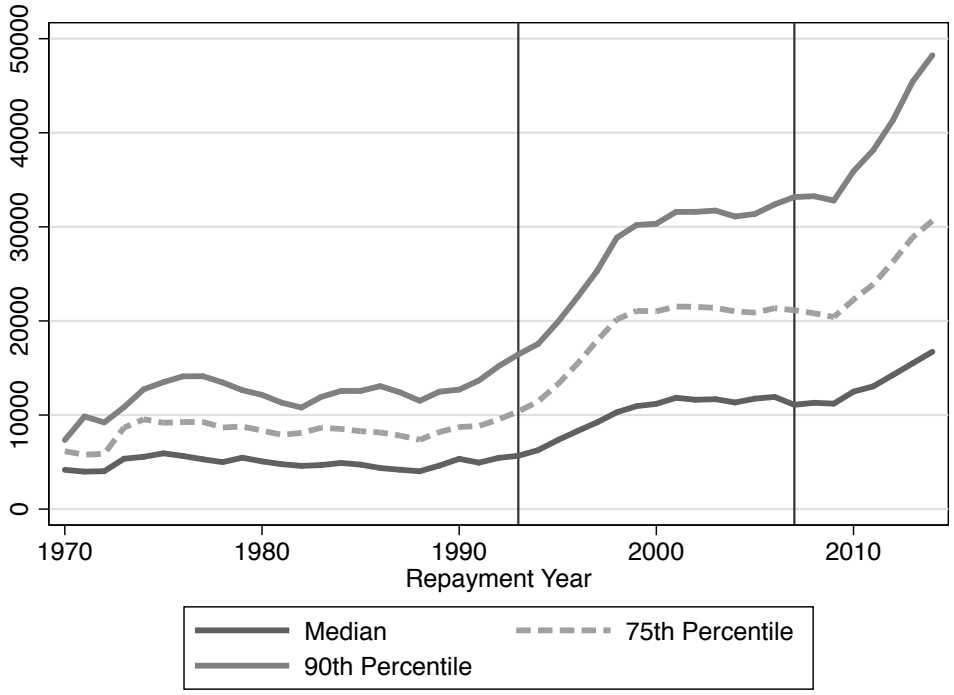


Figure A.3: Evolution of undergraduate student debt and number of postgraduate students

This figure shows changes in mean undergrad student debt in the year of repayment (right axis) and the number of graduate students. The source for undergraduate borrowing is Looney and Yannelis (2015). The source for graduate enrollment is the Integrated Postsecondary Education Data System (IPEDS).

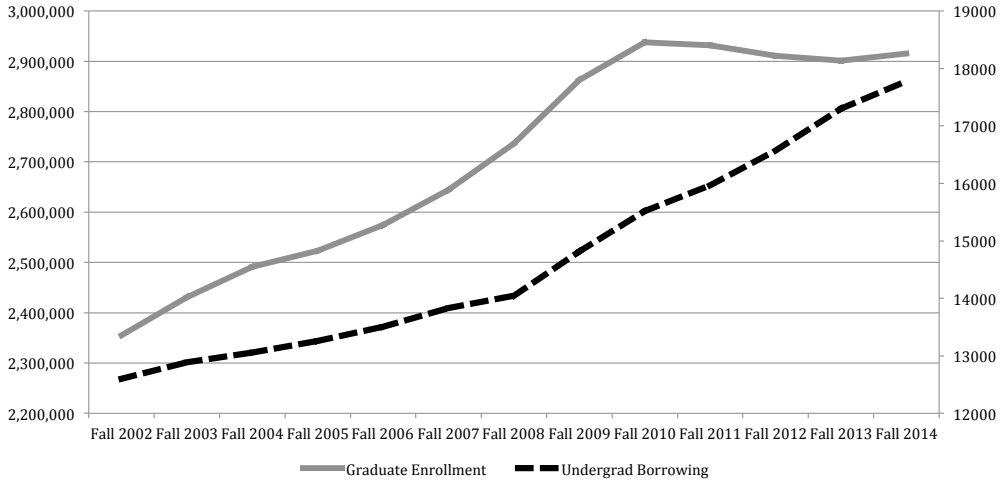


Table A.I: Tuition increases and student debt: reduced form

This table reports estimates of first stage regression (2), where *Debt* is replace with *Postgraduate*. Columns 1 and 2 show the differential effect of tuition increases on different cohorts. Columns 3 and 4 show the effect of tuition increases on different groups of cohorts. All regressions include year of tuition change by school fixed effects. Heteroskedasticity-robust standard errors (in parentheses) are clustered at school-year level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

Dependent variable: *Postgraduate*	(1)	(2)	(3)	(4)
$\Delta Tuition \times \delta^{c=1}$	-0.0294***	-0.0291***		
	(0.0071)	(0.0071)		
$\Delta Tuition \times \delta^{c=2}$	-0.0272***	-0.0256***		
	(0.0065)	(0.0065)		
$\Delta Tuition \times \delta^{c=3}$	-0.0138**	-0.0129**		
	(0.0064)	(0.0063)		
$\Delta Tuition \times \delta^{c=4}$	-0.0112	-0.0109		
	(0.0083)	(0.0082)		
$\Delta Tuition \times \delta^{c=5}$	-0.0057	-0.0057		
	(0.0070)	(0.0069)		
$\Delta Tuition \times \delta^{g=1}$			-0.0262***	-0.0251***
			(0.0066)	(0.0065)
$\Delta Tuition \times \delta^{g=2}$			-0.0105*	-0.0099*
			(0.0055)	(0.0053)
Controls	No	Yes	No	Yes
R^2	0.224	0.234	0.224	0.234
Obs.	265,006	265,006	265,006	265,006

Table A.II: IV effects with a restricted linear relationship

This table reports estimates of an IV regression of the causal effect of debt on the probability of enrolling in a postgraduate degree, where the instrument is the interaction of grade at the time of a tuition increase multiplied by the size of a tuition increase. All regressions include year of tuition change by school fixed effects. Heteroskedasticity-robust standard errors (in parentheses) are clustered at school-year level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

Dependent variable: *Postgraduate*		
	(1)	(2)
Debt	-0.0981***	-0.0705**
	(0.0301)	(0.0309)
Controls	No	Yes
Obs.	265,006	265,006

Table A.III: Student debt and student characteristics: placebo test

This table reports estimates of second stage regression (3), where *Postgraduate* is replace with student characteristics, such that family income, gender, number of children, and having an associate degree. First stage results are reported in Table IV. All regressions include year of tuition change by school fixed effects. Heteroskedasticity-robust standard errors (in parentheses) are clustered at school-year level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

Dependent variable:	Postgraduate	Female	Children	Dependents	Selectivity
	(1)	(2)	(3)	(4)	(5)
Debt	-3310.8	0.00490	0.0389	-0.0525	-0.0000
	(2352.8)	(0.0439)	(0.0598)	(0.0394)	(0.0004)
Controls	Yes	Yes	Yes	Yes	Yes
Obs.	265,006	265,006	265,006	265,006	265,006

Table A.IV: The effects of student debt on graduate studies: alternative definition of large tuition changes

This table reports estimates of second stage regression (3) where we replace the definition of large tuition changes to 25% change relative to the previous year. All regressions include year of tuition change by school fixed effects. Heteroskedasticity-robust standard errors (in parentheses) are clustered at school-year level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

Dependent variable: *Postgraduate*		
	(1)	(2)
Debt	-0.0843***	-0.0911***
	(0.0143)	(0.0140)
Controls	No	Yes
First stage	Cohorts	Cohorts
Obs.	265,006	265,006

Table A.V: States requiring mandatory financial education

This table lists the US states that require mandatory personal finance education as a graduate requirement for high-school, and the year in which the requirement was established. Source: Brown, Collins, Schmeiser, and Urban (2014).

State	Year Required	State	Year Required
Alabama	None	Montana	None
Alaska	None	Nebraska	None
Arizona	2005	Nevada	None
Arkansas	2005	New Hampshire	1993
California	None	New Jersey	2011
Colorado	2009	New Mexico	None
Connecticut	None	New York	1996
Delaware	None	North Carolina	2007
Florida	2014	North Dakota	None
Georgia	2007	Ohio	None
Hawaii	None	Oklahoma	None
Idaho	2007	Oregon	2013
Illinois	1970	Pennsylvania	None
Indiana	None	Rhode Island	None
Iowa	2011	South Carolina	2009
Kansas	2012	South Dakota	2006
Kentucky	None	Tennessee	2011
Lousiana	2005	Texas	2007
Maine	None	Utah	2008
Maryland	None	Vermont	None
Massachussets	None	Virginia	2014
Michigan	1998	Washington	None
Minnesota	None	West Virginia	None
Mississippi	None	Wisconsin	None
Missouri	2010	Wyoming	2002