Tuition Effects of IDR Plans: Evidence from the Introduction of the PAYE Repayment Plan

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Abstract

We study the effects of an increase in the generosity of income-driven repayment (IDR) plans on net tuition (tuition less school-provided financial aid) using policy-induced variation from the introduction of the Pay As You Earn (PAYE) repayment plan in 2012. We estimate future wages and the present value of loan repayment savings based on student SAT score, college, major, gender, race, parents' income, and other attributes. Using a triple difference framework, we find that selective colleges increase their net tuition to capture about $42 for every $100 in potential loan repayment savings; this effect is statistically insignificant and negligible for non-selective colleges. As an application, we estimate that President Biden's proposed SAVE plan would effectively transfer about $23 billion to selective colleges over the next 10-year budget window.

Keywords: Student loans, income-driven repayment plan, net tuition.
JEL Codes: I22, I23, I28.

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1 Introduction

The tuition price response to the increase in federal student aid availability has been traditionally summarized by the framework of the Bennett hypothesis, which states that if government funding and financial aid become more readily available to students, colleges and universities will be able to raise tuition costs more easily (Bennett, 1987). Although initially framed in the context of federal loan subsidies, the Bennett hypothesis has been applied to expansions in other types of financial aid, such as federal grants. In this paper, we investigate the Bennett hypothesis in the context of federal subsidies to student borrowers associated with the repayment schedules available to them after graduation. In particular, we study whether making income-driven repayment (IDR) plans more generous increases the net tuition (i.e., sticker price tuition net of any college-provided financial aid) charged to the undergraduate students who, on expectation, are more likely to benefit from the implied subsidies of the IDR plans.

IDR plans are intended to ease the burden of repayment by linking loan payments to the borrower's income and, in general, can be characterized by two policy parameters: the cap on the monthly payment amount expressed as a share of the borrower's income (or discretionary income) and the length of the repayment period. We leverage policy-induced variation resulting from the introduction of the Pay As You Earn (PAYE) repayment plan in December of 2012 that reduced monthly loan payments from 15% to 10% of the borrower's discretionary income and shortened the duration of the repayment period before debt forgiveness from 25 to 20 years, relative to the most generous IDR plan available on the market at the time.[1] For a given level of student loan debt and repayment circumstances, these modifications implied larger expected subsidies to borrowers in the form of forgiven balances by the end of the repayment period.

To estimate the effect of the introduction of PAYE on net tuition, we leverage restricted-use, student-level data from five waves of the National Postsecondary Student Aid Study (NPSAS) and a complete 10-year panel of the Baccalaureate and Beyond Longitudinal Study (B&B). We first simulate the present value of all future federal loan payments for repeated cross-sections of enrolled undergraduate students under the default standard ten-year repayment plan and the PAYE plan, including those who do not effectively borrow and those attending college before the new plan was introduced. Using a difference-in-differences strategy, we then compare the net tuition charged by colleges to students with positive potential lifetime savings in loan payments from participating in PAYE (i.e.,

[1] The years following 2012 saw modifications of pre-existing IDR plans that, broadly speaking, made their terms similar to the PAYE repayment plan. We see the PAYE rules as a good proxy for all the updated plans. See Baum and Delisle (2022) for a discussion.

the *treatment* group) with the net tuition charged to those with zero potential lifetime savings in loan payments (i.e., the *comparison* group), before and after the plan's introduction. Since, as we show, students in these two groups tend to disproportionally come from undergraduate majors that experienced dissimilar trends in enrollment over time during the analysis period, comparing net tuition trends between them can result in biased tuition effect estimates. Our main design circumvents this issue by following a triple difference strategy that also uses the fact that within these two groups, some students did not apply for federal financial aid (which is observed by the colleges). While institutions should not change net tuition in response to PAYE for these students, as they are not expected to benefit from the new subsidies, they were arguably exposed to the same major-specific trends in tuition. Our triple difference approach, therefore, allows us to net out these within-treatment group trends.

Our findings suggest that among students attending selective colleges, annual net tuition increased on average by $42.31 for every $100 in potential savings in lifetime loan payments derived from the increased generosity of the available IDR plans. In contrast, we find a statistically insignificant and economically negligible pass-through for students attending less selective colleges. Overall, we see a significant net tuition increase of $19.12 per $100 in potential loan repayment savings among four-year public and private non-profit institutions. The tuition effect is driven by selective colleges, as these elite institutions likely enjoy greater market power, allowing them to engage in more price discrimination (Fillmore, 2023).

We contribute to the literature on the Bennett hypothesis, which we review in the next section, by adding federal subsidies derived from IDR-related loan forgiveness to the types of aid studied previously. To our knowledge, our analysis is the first to examine how changes in IDR plans affect tuition for four-year undergraduate students. Much of the existing literature has been concerned with estimating tuition changes in response to more direct increases in federal aid funds, such as increases in federal student loan limits and maximum Pell Grant award amounts. Compared with these types of student aid, subsidies from loan forgiveness in IDR plans are not available to students at enrollment and only materialize once the repayment period is completed. Therefore, there is relatively more uncertainty surrounding these funds from the perspective of both the students and the colleges. Moreover, due to their complexity, students may not fully grasp the extent of the implicit subsidies stemming from more generous IDR plans. However, some evidence exists that colleges incorporate IDR-related loan forgiveness in pricing schemes for graduate students.[2] With a projected average subsidy rate of more than

[2]See Kelchen (2019) and references there.

25% among undergraduate borrowers, subsidies granted through loan forgiveness in IDR plans in the coming years are expected to be substantial. The Congressional Budget Office (CBO), for example, estimates that more than $100 billion of Direct student loans disbursed to undergraduate borrowers would be forgiven through IDR plans in the next 10-year budget window.[3] Given the increased importance of these IDR-derived subsidies within the college financing landscape, empirically investigating their potential effect on tuition is a policy-relevant issue.

The remainder of this paper is organized as follows: In the next section, we provide an overview of IDR plans in the United States and a brief literature review of the recent evidence on the Bennett hypothesis. The third section describes our data sources and details the construction of the key variables used in our analyses. The fourth section discusses our identification strategy and estimation approaches. The fifth section presents our empirical results, and section six includes some robustness checks. Finally, section seven concludes.

2 Background

This section provides an overview of the available IDR plans in the United States and a short review of the related literature surrounding the Bennett hypothesis for different types of student aid.

2.1 Income-Driven Repayment Plans

An income-driven repayment plan is one of the two general repayment options available to most federal student loan borrowers in the United States. Unlike the default ten-year standard repayment plan, IDR plans are designed to make it more manageable for borrowers to repay their federal student loans by tying the monthly loan payments to their income and family size. The key feature of IDR plans is that they cap the monthly payment amount at a percentage of the borrower's discretionary income (i.e., income after covering basic needs). In contrast, the ten-year standard repayment plan requires fixed monthly payments under a schedule similar to a ten-year mortgage (Karamcheva et al., 2020). The standard plan is the default option in which student borrowers would be automatically enrolled unless they opt-in to another plan. Before 2010, most borrowers in repayment were enrolled in the default standard plan, with only a small fraction of

[3] See, for example, detailed information underlying CBO's 10-year budget projections for Student Loan Program in 2024 here: https://www.cbo.gov/system/files/2024-06/51310-2024-06-studentloan.pdf.

borrowers opting for alternative repayment options, including IDR plans (Herbst, 2023). Figure 1 shows IDR participation trends by dollars outstanding and number of loan recipients in IDR plans in the last decade. Between 2013 and 2023, the share of total Direct Loan dollars outstanding being paid through IDR plans went up from 20% to 42%, amounting to $453.4 billion in 2023. In turn, the share of Direct Loan borrowers enrolled in IDR plans grew from 10% to 32%.

Different IDR plans are available to student borrowers. These plans come with distinct sign-up restrictions, features, and implied levels of generosity. Below, we include some of the key features of the plans. A more detailed description of these plans (except for the recently introduced SAVE plan), particularly related to their eligibility criteria, can be found in Karamcheva, Perry, and Yannelis (2020).[4] Baum and Delisle (2022) also offer a brief history of IDR plans in the United States.

- **Income-Contingent Repayment (ICR)** plan. Introduced in 1994, it is the oldest IDR plan. It caps payments at 20 percent of the borrower's discretionary income or what the borrower would pay on a fixed 12-year repayment plan, whichever is less. The repayment period before forgiveness is 25 years.

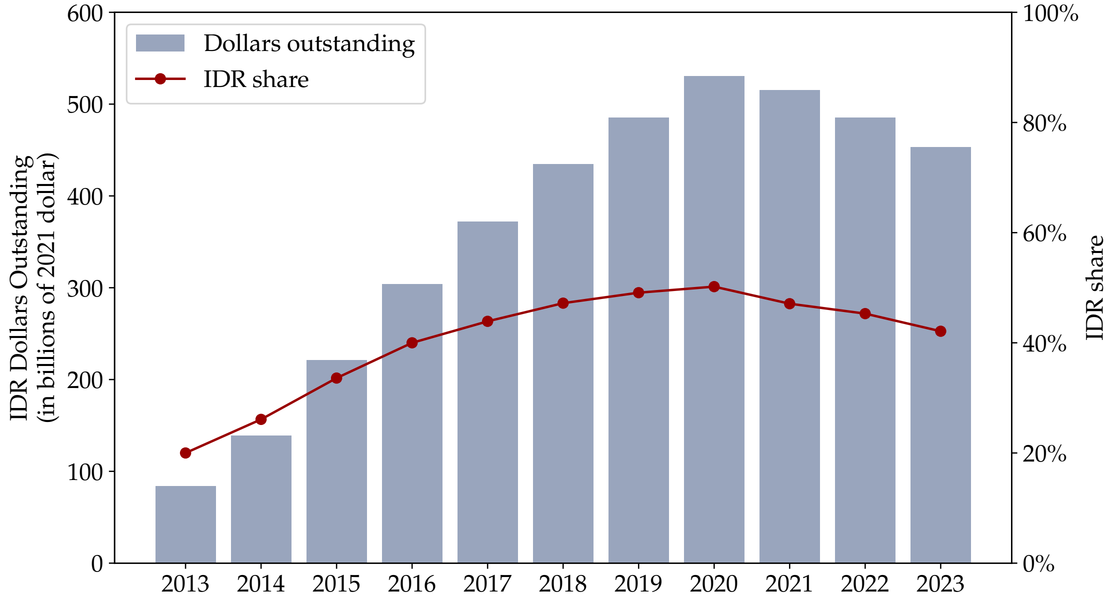
- **Income-Based Repayment (IBR)** plan. Introduced in July 2009, this plan originally set the monthly payments at 15 percent of the borrower's discretionary income and the repayment period to 25 years. Later, in July 2014, the payments were lowered to only 10 percent of the discretionary income, and the time until forgiveness was set to 20 years. Payments are capped at what the borrower would pay under the ten-year standard repayment plan.

- **Pay As You Earn (PAYE)** plan. Introduced in December 2012, the PAYE plan caps the monthly payments at 10 percent of the borrower's discretionary income and ensures that this payment never exceeds the one under the ten-year standard repayment plan. The repayment time until forgiveness is set to 20 years. This plan is the focus of our analysis.

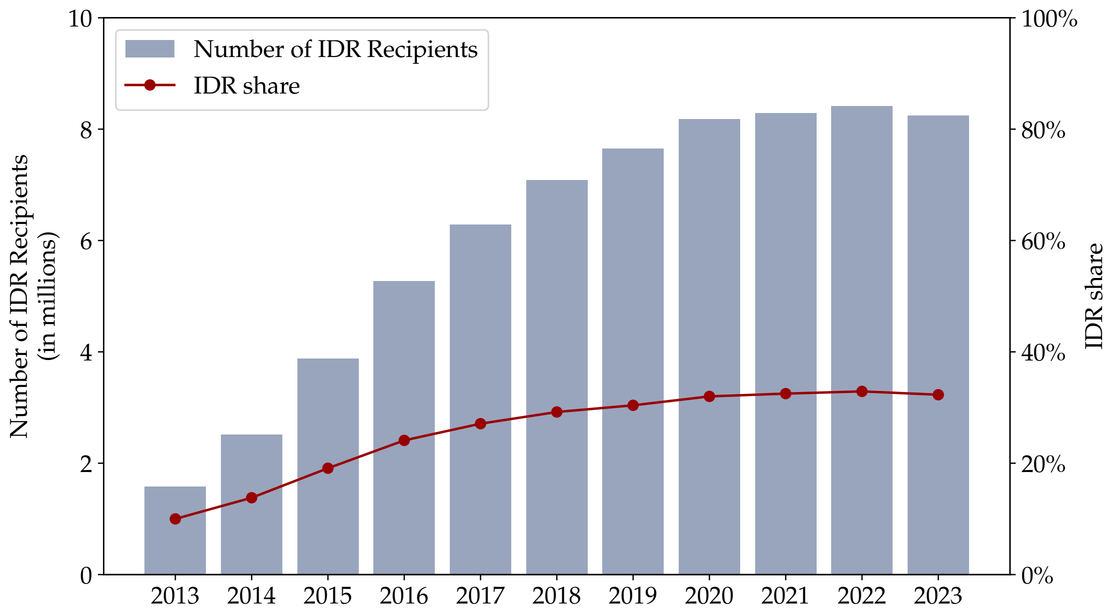
- **Revised Pay As You Earn (REPAYE)** plan. Introduced in December 2015, this plan is similar to PAYE but provides eligibility to an expanded set of borrowers, particularly those with older loans. It caps payments at 10 percent of the discretionary income, and loan balances are forgiven after 20 or 25 years of qualifying payments, depending on whether the borrower has undergraduate or graduate loans.

[4]More information about the SAVE plan can be found here: https://studentaid.gov/announcements-events/save-plan.

Figure 1. Direct Loan Portfolio in IDR: Dollars Outstanding and Number of Recipients



(a) Dollars outstanding and IDR share



(b) Number of Recipients and IDR share

Notes: This figure plots dollars outstanding and the number of recipients in IDR plans. Numbers include outstanding principal and interest balances of Direct Loan borrowers in Repayment, Deferment, and Forbearance. The IDR share in panel (a) is calculated as the ratio of total Direct Loan dollars outstanding in IDR plans to the total Direct Loan dollars outstanding. The IDR share in panel (b) is calculated as the number of Direct Loan recipients in IDR plans over the total number of Direct Loan borrowers. Money variables are measured in constant 2021 U.S. dollars.
Source: U.S. Department of Education, Federal Student Loan Portfolio, National Student Loan Data System (NSLDS). https://studentaid.gov/data-center/student/portfolio.

- **Saving on a Valuable Education (SAVE)** plan. This is the newest IDR plan, which was introduced in August 2023. SAVE replaces the REPAYE plan and changes the payment cap to only 5 percent for undergraduate loans (the 10 percent for graduate loans is kept unchanged). Forgiveness starts at ten years for those borrowers with original balances of $12,000 or less, and the repayment period before forgiveness increases by one year for every additional $1,000 borrowed. Moreover, the SAVE plan re-defined the discretionary income as the borrower's adjusted gross income (or AGI) minus 225% of the federal poverty line (instead of the previous 150% of the poverty line for all other IDR plans).

Any loan balances remaining at the end of the repayment period are forgiven for borrowers in all IDR plans. All other things equal, a decrease in the repayment share of discretionary income would bring more unpaid loan balances to forgiveness, which is technically equivalent to an increased subsidy to student borrowers.[5] As summarized by the Bennett hypothesis, we argue that this increased generosity of the government subsidy gives colleges and universities incentives to respond by raising their tuition prices. We aim to test this possibility empirically.

2.2 Related Literature

Lucca, Nadauld, and Shen (2019) found a pass-through effect on sticker tuition in response to changes in subsidized loan maximums amounting to approximately 60 cents per dollar and smaller yet positive effects for unsubsidized federal loans following the $2,000 increase in maximum federal student loans during the 2008-2009 period. The authors constructed an institution's "exposure" to the subsidized loan policy adjustment by calculating the proportion of undergraduate students who borrowed subsidized loans at the maximum allowable level in 2004 (pre-policy change). This measure served as a proxy for the fraction of students likely to take advantage of the policy modification to access additional subsidized loans.

Black, Turner, and Denning (2023) investigated the effect on sticker and net prices of the effective removal by the federal government of the borrowing limit for graduate programs following the introduction of the Graduate PLUS loan program in 2006. They found that institutions and programs with a larger share of students constrained by federal loan limits in the periods preceding the introduction of Grad PLUS witnessed notably higher increases in federal borrowing and tuition prices subsequent to the implementa-

[5]Some student borrowers would still fully repay their loan balances under the new rules, either because they do not enroll in the IDR plan or have relatively high earnings.

tion of Grad PLUS. According to their estimates, a one-dollar increment in federal loans was associated with a substantial \$1.16 surge in the listed price of a program, alongside a \$0.66 increase in net prices.

In the context of Parent Loans to Undergraduate Students (PLUS), Kargar and Mann (2023) exploit an inward demand shock that occurred in October 2011 due to the tightening of credit standards, which disqualified many parents from PLUS loan eligibility. Using the fraction of aid recipients that came from low-income families in 2010 as the cross-sectional measure of treatment exposure, they document that relative growth in tuition slowed at colleges more affected by the tightening of credit standards. They conclude that "students likely capture less than \$0.60 of each dollar of public funds spent on loan subsidies."

Turner (2017) examined the economic incidence of the Pell Grant subsidies using regression discontinuity (RD) and regression kink (RK) designs. She estimated that approximately 11-20 percent of Pell Grant aid is funneled to educational institutions. This estimation considers both scenarios: a) when students receive an additional dollar of Pell Grant aid, and b) when students are categorized as Pell Grant recipients. Also within the context of the Pell Grant subsidies, Singell and Stone (2007) found evidence supporting the validity of the Bennett hypothesis concerning private universities and the out-of-state tuition at public universities. They observed a nearly proportional increase in tuition in response to changes in Pell Grant subsidies. However, their findings revealed limited evidence supporting the Bennett hypothesis in the context of in-state tuition for public universities. Notably, the observed responsiveness of out-of-state tuition to fluctuations in the average Pell Grant contrasts with the lack of similar responsiveness in in-state tuition. This dichotomy suggests that public universities may be subject to explicit or implicit constraints aimed at preserving affordable access for in-state students, while not necessarily extending the same considerations to out-of-state students.

The literature on the Bennett hypothesis focusing on IDR is rather limited. Kelchen (2019) and Kelchen (2020) looked at the introduction of the 2006 Grad PLUS expansion as well as the 2007 IBR and the corresponding tuition price changes in law schools, business schools, and medical schools, which mainly affect graduate students. After reporting insufficient evidence supporting the Bennett hypothesis in these contexts, the author proposes that this may stem from students transitioning from private loans to PLUS loans, thereby already having access to loans covering the entire cost of attendance.

3 Data and Key Variables

This section describes our data sources and provides details on the construction of the key variables used in our analyses. We use restricted-use, individual-level data from five waves of a nationally representative cross-sectional sample of enrolled undergraduate students to track net tuition prices over time. We employ data on income trajectories and cumulative federal student loans from a nationally representative longitudinal sample of college graduates combined with Census data to simulate students' future income trajectories and cumulative federal student loan amounts within our repeated cross-sectional samples of still-enrolled undergraduate students. Combined, this information allows us to assess the impact of the increased generosity of the IDR plans due to the introduction of the PAYE option on net tuition prices.

3.1 Data Sources

We construct our main analysis sample by pooling individual-level data derived from the restricted-use National Postsecondary Student Aid Study (NPSAS) for undergraduate students collected in academic years 2003-04, 2007-08, 2011-12, 2015-16, and 2017-18 by the National Center for Education Statistics (NCES) of the United States Department of Education. We also employ similar data from the Baccalaureate and Beyond Longitudinal Study (B&B), also collected by the NCES, for the 2007–08 cohort of graduates to create the key variables used in our main analysis. Finally, we also utilize auxiliary information from the U.S. Census Bureau's 2009 American Community Survey (ACS) (Ruggles et al., 2024).

The NPSAS contains information from a nationally representative sample of students attending Title IV postsecondary institutions in the United States during a given academic year (NCES, 2024b). The study sources data from institutional records, government databases, and student interviews. Comprehensive enrollment and financial aid information is obtained from institutional records, while additional demographic and background data are collected directly from the students (NCES, 2024b).

The B&B follows a nationally representative sample of bachelor's degree recipients over ten years, collecting data on labor market participation, earnings, student debt and repayment dynamics, and graduate school attendance (NCES, 2024a). We use data from the B&B 2008–2018 (B&B:08/18) that contains relatively recent and detailed information about students' undergraduate field of study and demographics, as well as first-year, fourth-year, and tenth-year post-college graduation income information, which serves as a good reference for us to predict students' future earnings trajectories. Specifically, we use the rich information on cumulative federal student loan amounts and income trajectories in the B&B to predict the future income and debt for the still-enrolled students in our main NPSAS samples.

3.2 Construction of Key Variables

An intuitive way to identify whether and how much each student might be affected by the IDR policy change is to calculate the expected savings or subsidy amount from opting into the new PAYE plan. To construct this exposure variable (subsequently *Repayment Savings* or *RS*), we require information on each student's potential income trajectory, cumulative federal student loan amount borrowed, and an estimate of the total present value of all future payments under different repayment plans.

3.2.1 Income Trajectory Prediction

Our pooled NPSAS sample contains data on institutional and student characteristics, including sticker price tuition, institutional aid, and net tuition, but not on post-enrollment earnings or cumulative student loan debt since the NPSAS information is a snapshot compiled while students are still enrolled in college. We combine data from the B&B:08/18 survey and the 2009 American Community Survey (ACS) to impute students' future income trajectories within our NPSAS cross-sectional samples. Specifically, the B&B:08/18 data contains information on annual income one year after, four years after, and ten years after bachelor's degree completion for students graduating in the 2007-08 academic year. Using this information, we run ordinary least squares (OLS) regressions for years $\tau = 1, 4, 10$ as follows:

$$Log(PostGraduationIncome_{i,\tau}) = X_i \Gamma_\tau + \delta_{j(i),\tau} + \lambda_{c(i),\tau} + \varepsilon_{i,\tau}, \tag{1}$$

where X_i is a vector of student characteristics, including gender, race/ethnicity, and SAT score. For the four-year and ten-year after-graduation income predictions, we also include the lag of income at year one and year four, respectively. Previous literature has shown that college majors — field of study — highly influence students' lifetime earning trajectories (Altonji, Blom, and Meghir, 2012; Webber, 2014; Altonji, Arcidiacono, and Maurel, 2016; Kirkeboen, Leuven, and Mogstad, 2016). To account for this, we include field of study indicators, $\delta_{j(i)}$.[6] Finally, $\lambda_{c(i)}$ are college indicators and ε_i is an error term.

[6] We follow Webber (2014) and use five major category groupings: STEM, Business, Social Science, Arts and Humanities, and Other. Table A1 in the appendix shows the majors included in each of these groups.

Using the fitted coefficients from these three models, we impute each student's annual income at years one, four, and ten after college graduation in the pooled NPSAS sample. For the years in between, we impute the income using a linear interpolation. For income information starting in year 11 after college graduation, we grow earnings employing income profile parameters estimated from the 2009 ACS data based on individual demographic characteristics.

We incorporate some randomness into the process to add more realistic heterogeneity to the individual income profiles. Specifically, we assume that the log of the annual income of student i at year t after college graduation follows:

$$Log(Income_{it}) = Log(\widehat{PostGraduationIncome_{i,t}}) + \Delta_{it} + z_{it} + \mu_{it}, \tag{2}$$

where $Log(\widehat{PostGraduationIncome_{i,t}})$ is the predicted (deterministic) income derived from Equation 1; Δ_{it} is the expected annual change in log income estimated from the ACS by sex-by-race groups for years 11-20 of potential experience after college graduation ($\Delta_{it} = 0$ for $t \leq 10$); $z_{it} = z_{it-1} + \eta_{it}$ is the slowly evolving permanent component of income, with $\eta_{it} \sim N(0, 0.086)$; and μ_{it} is a transitory shock also normally distributed, $\mu_{it} \sim N(0, 0.196)$. We take the parameters for the income process from Guvenen, McKay, and Ryan (2023). Table A2 presents detailed estimates for Δ_{it} by sex and race/ethnicity derived from the 2009 ACS data. Finally, since the B&B:08/18 data we use to estimate Equation 1 only reflects the income trajectory of the graduating cohort of the academic year 2007-08, we also allow real income to grow (decrease) at approximately 0.3% annually for subsequent (previous) cohorts according to their expected graduation year.

Following Catherine and Yannelis (2023), for each student, we simulate one thousand income trajectories using the procedure above and average them to accurately compute the expected value of the student's payment under PAYE. Figure A1 shows the resulting simulated income paths by major groups for years 1-20 post-completion of bachelor's degree. STEM and Business majors tend to make more than Social Sciences and Arts and Humanities majors. The ranking and general shape of these profiles match the ones in Webber (2014).

3.2.2 Cumulative Student Loan Prediction

We also use B&B:08/18 data for the college students' cumulative federal student loan amount prediction. Specifically, we run the following OLS regression on the sample of students with positive loan amounts:

$$CumulativeStudentLoan_{i,10} = X_i\Pi + Z_{c(i)}\Gamma + \varepsilon_i, \tag{3}$$

where X_i is a vector of student characteristics, including gender, race/ethnicity, SAT score, dependency status when enrolled, and annual family income when enrolled in college. These variables significantly influence students' decisions on how much federal loans they borrow. $Z_{c(i)}$ s a vector of institutional characteristics, including whether the college is a public or private non-profit institution and its selectivity level as defined by the NCES (up to "very selective," "moderately selective," "minimally selective," and "open admission"). Similar to the income trajectory prediction, we increase the estimated cumulative loan amount for graduating cohorts after the 2003-04 academic year by 0.4% annually, based on their expected graduation year, to account for the recent growing trends in federal student loan borrowing.

Here, $CumulativeStudentLoan_{i,10}$ is the observed cumulative federal student loan for both undergraduate and graduate studies (if any) ten years after college graduation. The reasoning for the utilization of the variable is twofold. Firstly, from the institution's perspective, it is plausible that educational institutions can preemptively discern whether a student borrower is inclined to pursue graduate-level studies. Consequently, this foresight enables the institutions to estimate the extent to which students may engage in higher or lower cumulative federal student loan borrowing. Secondly, for methodological coherence with the post-graduation earnings prediction and simulation derived from the B&B:08/18 dataset, we employed the entire sample of students who finished their bachelor's degree, regardless of whether they enrolled in a graduate program since the sample of students with only a bachelor's degree would be too small for us to predict post-graduation earnings accurately. In fact, 46% of bachelor's degree graduates in the 2007-08 B&B cohort enrolled in a post-baccalaureate education program within ten years of finishing college.

The average predicted student loan amount for the NPSAS sample is $37,095, which aligns well with the actual positive average federal student loan debt amount for these selected years.

3.2.3 Repayments Present Value Calculation

To calculate the *Repayment Savings* for each student, we need to calculate the present value of all future payments under the standard repayment plan and the newly introduced PAYE plan.[7] Therefore, we first calculate the annual payment under the 10-year standard plan using the standard amortization schedule:

$$Payment_{it}^{\text{Standard}} = 12 \times \widehat{CumulativeStudentLoan}_{i,10} \times \frac{c(1+c)^{120}}{(1+c)^{120}-1}, \tag{4}$$

where c stands for the student loan's monthly interest rate in the issuance year.[8] Next, we calculate the annual payment under PAYE using the introduced rules:

$$\mathbb{E}\left[Payment_{it}^{\text{PAYE}}\right] = \min\left\{Payment_{it}^{\text{Standard}}, \max\{0.1 \times (Income_{it} - 1.5 \times FPL_t), 0\}\right\}, \tag{5}$$

where $Income_{it}$ is the income for student i at year t, and FPL_t is the federal poverty line, which evolves with inflation growth adjustment.[9] Under both plans, payments are zero once the loan is fully paid back.

Next, we calculate the total present value of the future payments under both the standard and PAYE plans:

$$TPV_i^j = \sum_{t=1}^{20} \frac{\mathbb{E}[Payment_{it}^j]}{(1+r)^t}, \tag{6}$$

where $j \in \{\text{Standard, PAYE}\}$, r is the interest rate on Treasury securities from the year of the loan's disbursement with maturities that match the timing of the cash flows (Karamcheva et al., 2020), accounting for the temporal variation in interest rates.[10]

And finally, we calculate the difference between the two total present values:

$$RS_i = \max\{TPV_i^{\text{Standard}} - TPV_i^{\text{PAYE}}, 0\}. \tag{7}$$

[7] One alternative way to construct this Repayment Savings variable is to calculate the present value difference between the (old) IBR and PAYE. However, as shown in Figure 2-1 and Figure 2-2 of Karamcheva et al. (2020), most student borrowers chose the standard fixed-payment plan before 2010. Between 2010 and 2017, the total balance of loans in IDR plans grew from \$24 billion (a 12 percent share) to \$384 billion (a 45 percent share) (Karamcheva et al., 2020). See also our Figure 1. Notably, a significant surge in participation in IDR plans only materialized in the 2013-2014 period, coinciding with PAYE's introduction. Therefore, we adhere to formulating the present value difference between the standard plan and the PAYE plan.

[8] We take the average of Direct Subsidized and Direct Unsubsidized loans across both undergraduate and graduate borrowers. These rates are 3.82%, 6.80%, 5.95%, 4.81%, and 4.97% for the freshmen cohorts of 2003-2004, 2007-08, 2011-12, 2015-16, and 2017-18, respectively.

[9] The federal poverty guidelines are maintained by the U.S. Department of Health and Human Services. For years before 2023, we use the actual federal poverty guideline data extracted from https://aspe.hhs.gov/topics/poverty-economic-mobility/poverty-guidelines. For years after 2023, we grow the federal poverty guideline with the predicted inflation rate.

[10] Because the standard plan only lasts for ten years, for $t = \{11, \ldots, 20\}$, $\text{Payment}_{it}^{Standard} = 0$.

The variable RS_i is the student-level *Repayment Savings*, quantifying the extent to which an individual student benefits from the PAYE introduction. RS_i is our key individual-level treatment variable. The non-negativity of RS reflects the fact that IDR plans provide value to all student borrowers. On expectation, every student gains from a positive subsidy due to the option value of IDR plans and the flexibility to enroll in it at any point. Universities, therefore, recognize this value and can potentially seek to capture part of the loan repayment savings by increasing tuition.

In our main analysis, we divide our sample into two groups: potential PAYE beneficiaries with $RS_i > 0$ and potential PAYE non-beneficiaries with $RS_i = 0$ to serve as our *treatment* group and *comparison* group, respectively. Furthermore, within our NAPSAS data, we are able to identify students who completed the Free Application for Federal Student Aid (FAFSA) and, therefore, are more likely, from the perspective of the college, to borrow from the federal government to pay for their education. We use these two within-treatment subgroups in our triple difference empirical strategy, which we describe in detail in the next section.

3.2.4 Outcome Variable

In our main analysis, we use net tuition as the dependent variable. Net tuition is calculated from the NPSAS as the annual sticker price tuition (TUITION2) minus any institutional aid (INGRTAMT). Our main analysis centers on assessing the causal impact of the introduction of the PAYE plan in December 2012 on institutions' net tuition prices. The rationale behind emphasizing net tuition, as opposed to either sticker price tuition or institutional aid, lies in the fact that net tuition closely reflects the final amount charged to students by colleges. Nevertheless, we also present the results of the decomposition of net tuition into sticker price tuition and institutional aid.

3.3 Analytic Sample and Summary Statistics

Our overall analysis sample contains student-level data from private non-profit four-year institutions and public four-year institutions from NPSAS in academic years 2003-04, 2007-08, 2011-12, 2015-16, and 2017-18. To facilitate comparisons between students with varying levels of RS within the same institution and to align our institution sample with the B&B data, we exclude students from special focus institutions and those enrolled in programs shorter than four years.[11] Furthermore, following Fillmore (2023), we restrict

[11] We are limited by our B&B data to only model income and loan amounts for individuals with at least a bachelor's degree.

the sample to students who only attended one institution during the academic year, who never received an athletic scholarship, and whose parents never earned a tuition waiver. We also dropped foreign students and students from Puerto Rico.

Similar to Fillmore (2023), we divide our empirical analysis sample into an "elite" sample and a "non-elite" sample according to the characteristics of the institutions students attend. Specifically, the elite sample includes all four-year private non-profit institutions, as well as four-year public institutions classified as "very selective" in the NPSAS data.[12] The non-elite sample contains all remaining four-year public institutions whose selectivity levels are classified as "moderately selective," "minimally selective," and "open admission." As described in Fillmore (2023), price discrimination through tuition discounting and personalized financial aid offers are mostly a phenomenon of elite colleges. We note, however, that the definition of an "elite" institution we employ is still pretty broad.

Our final analysis sample consists of 166,540 individual-level observations and 860 unique institutions. The elite sample contains 67,880 observations and 520 institutions, whereas the non-elite sample comprises 98,660 observations and 340 unique institutions.[13]

Table 1 presents the summary statistics of net tuition, sticker price tuition, institutional aid, *Repayment Savings*, estimated cumulative student loan amount, and FAFSA filing status for students in the elite sample, non-elite sample, as well as the overall sample of students, calculated using NPSAS survey weights. Relative to non-elite sample institutions, elite institutions have higher averages on the net tuition, tuition sticker price, and institutional aid, which serves as evidence that elite and non-elite colleges are substantially different in the market they serve and tuition discounting setting.

In terms of potential repayment savings, on average, students are expected to derive \$1,584 in subsidies from the PAYE plan. However, only about 22% of students would see positive savings relative to the standard plan, which is largely in line with the take-up rate of IDR during this period, with the standard plan remaining the dominant repayment option for student borrowers. The average *Repayment Savings* among those with a positive expected subsidy is \$7,135.

3.3.1 Trends in Tuition

Beyond changes in the availability of college funding, other factors, such as differential demand and supply shocks across programs and majors over time, influence college

[12]For a given institution, this classification can change between NPSAS rounds and so we fix it to the classification reported during the NPSAS 2007-08 for consistency with our B&B data.

[13]The numbers of observations and institutions are rounded to the nearest 10 per the Institute of Education Sciences (IES) restricted-use data guidelines.

Table 1. Summary Statistics of Key Variables

	Elite sample	Non-elite sample	All
Net tuition	15,062.70	7,261.43	10,396.15
	(12,781.60)	(5,948.59)	(10,071.77)
Tuition sticker price	20,759.60	8,371.15	13,449.10
	(16,374.34)	(6,666.54)	(13,084.72)
Institutional aid	5,865.43	1,215.39	3,083.88
	(10,543.65)	(3,411.44)	(7,538.49)
Institutional aid (if positive)	13,495.01	4,943.50	9,585.82
	(12,361.72)	(5,376.48)	(10,691.97)
Repayment Savings	1,608.41	1,567.28	1,583.81
	(6,206.86)	(5,582.68)	(5,841.55)
% with positive Repayment Savings	20.71	23.20	22.20
Repayment Savings (if positive)	7,766.76	6,756.33	7,135.12
	(11,755.90)	(9,964.69)	(10,682.67)
Cumulative Student Loan	37,789.40	36,629.21	37,095.40
	(9,415.07)	(9,086.13)	(9,237.24)
FAFSA filing status (0/1)	0.73	0.72	0.73
	(0.45)	(0.45)	(0.45)
N of observations	67,880	98,660	166,540
N of institutions	520	340	860

Notes: This table presents the means and standard deviations (in parentheses) of net tuition, sticker price tuition, institutional aid, *Repayment Savings*, and FAFSA filing status, calculated using NPSAS survey weights. Columns 1, 2, and 3 report the statistics among the elite sample, non-elite sample, and pooled overall sample, respectively. Money variables are measured in constant 2021 US dollars. *N* of observations and institutions are rounded to the nearest 10 per IES restricted-use guidelines.
Source: U.S. Department of Education, National Center for Education Statistics, 2003-2004, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), and 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC).

price-setting. In our analysis, it is crucial to disentangle the effect of these shocks on tuition prices from the effects of PAYE, as our goal is to isolate the average treatment effect of PAYE on net tuition. As we discuss later in subsection 5.1, the students in sub-groups with $RS > 0$ tend to be from majors such as Arts and Humanities and Social Sciences, while those in sub-groups with $RS = 0$ are more likely to come from majors like STEM and Business.

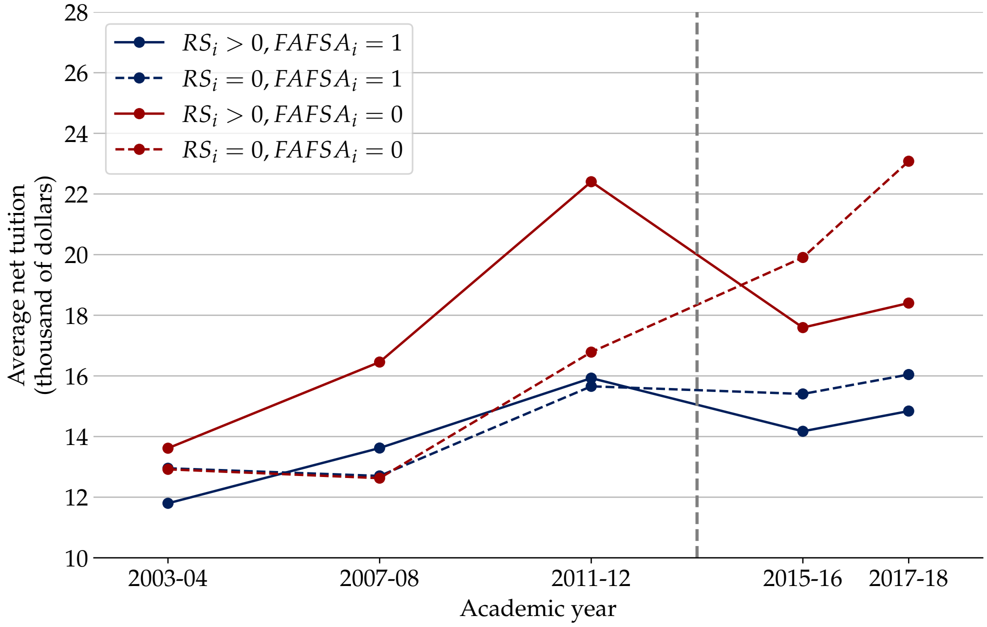
Figure A2 presents the number of bachelor's degrees awarded at public and private non-profit institutions by specific majors among the starting cohorts between 2007-08 and

2017-18.[14] Compared to Social Sciences and Arts and Humanities, where potential PAYE beneficiaries are concentrated, the number of bachelor's degrees awarded in STEM and Business fields has dramatically increased since 2010-11. This is especially notable for STEM majors (which include healthcare fields in our definition), which had more than 60 percent growth during this period. Beyond these demand factors, and likely influenced by them, from the supply side, (positive) differential pricing for majors like engineering, business, or nursing became more common during this period (Ehrenberg, 2012; Stange, 2015; Wolniak, George, and Nelson, 2018). For example, between 2008 and 2011, the share of major public research universities with differential tuition or fees by major increased by more than ten percentage points, with a more marked increase in flagship universities (Stange, 2015). Therefore, we introduce an intra-group comparison related to FAFSA filing status within the RS groups to address potential issues related to changes in demand and supply factors differentially affecting the net tuition of specific majors. The FAFSA filers and non-FAFSA filers within the RS groups should have experienced the same shocks that affected the charged tuition.

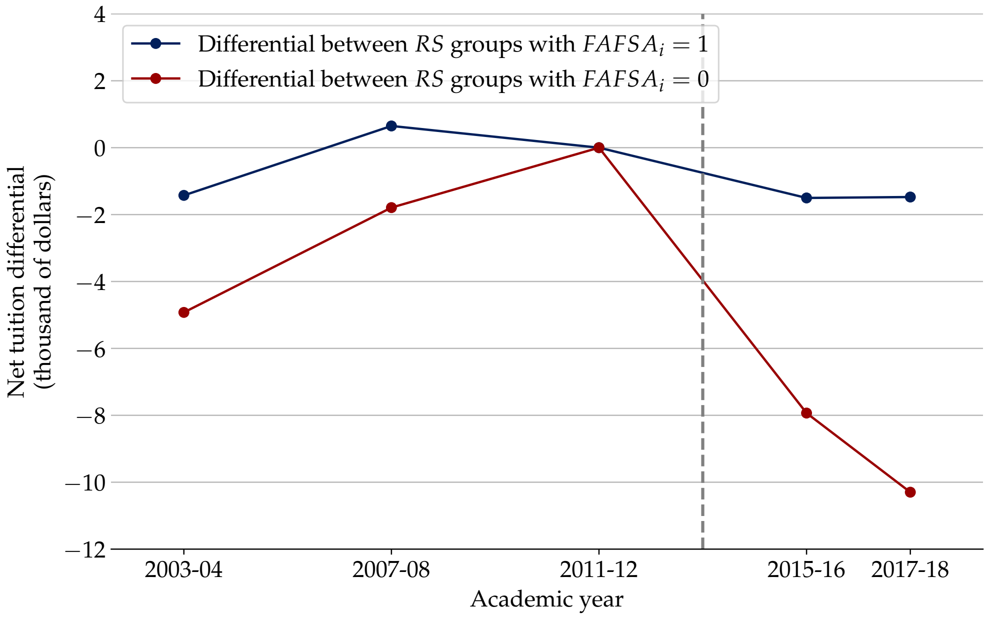
Figure 2a and Figure 3a present the raw trends in annual net tuition for four sub-groups for the elite and non-elite samples, respectively. The four sub-groups are PAYE potential beneficiaries who filed for FAFSA, PAYE potential non-beneficiaries who filed for FAFSA, PAYE potential beneficiaries who did not file for FAFSA, and PAYE potential non-beneficiaries who did not file for FAFSA. For the elite sample, there is a clear decrease in net tuition for the potential PAYE beneficiary sub-groups ($RS > 0$) between 2011-12 and 2015-16, likely related to the negative relative demand shock affecting the fields these students tend to major in (see Figure A2).

[14] These academic years are calculated as the actual completion/graduation year reported in the data minus four, serving as a proxy for the academic years of undergraduate enrollment.

Figure 2. Trends in Net Tuition: Elite Sample



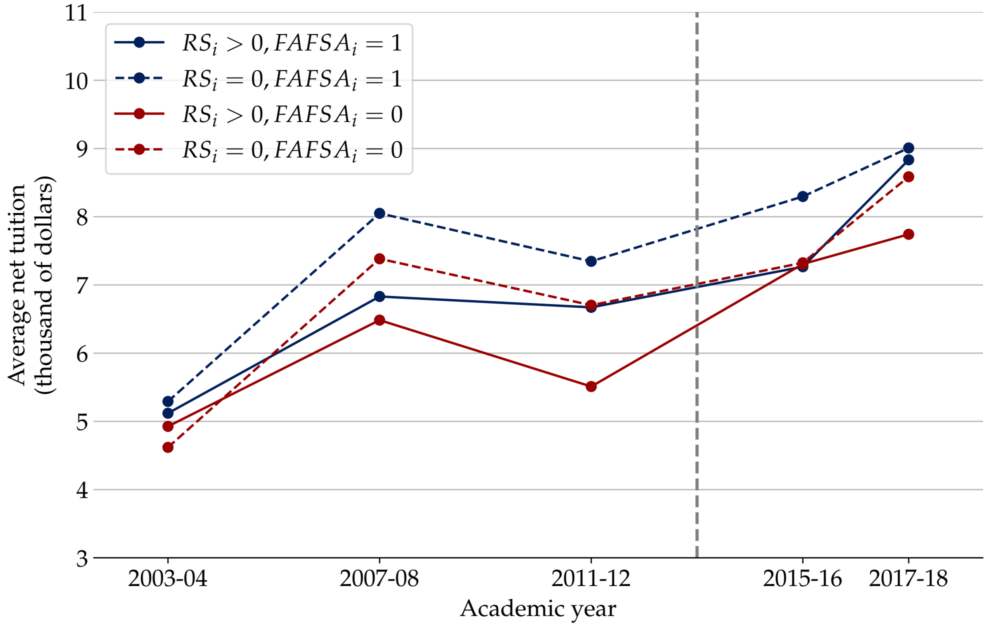
(a) Raw trends in net tuition by RS and $FAFSA$ sub-groups



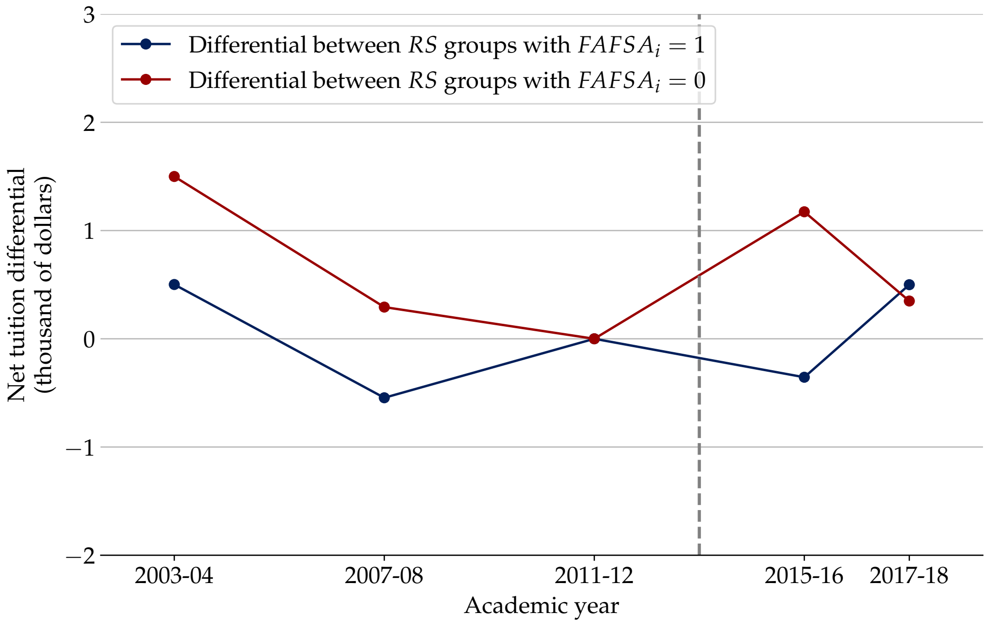
(b) Net tuition differentials between RS sub-groups by $FAFSA$ status relative to academic year 2011-12

Notes: This figure plots trends in average Net Tuition as defined in subsection 4.1 by RS and $FAFSA$ sub-groups, as well as the Net Tuition differentials between RS sub-groups by $FAFSA$ filing status relative to academic year 2011-12 for elite sample, calculated using NPSAS survey weights. The dotted line represents the introduction of PAYE which happened in late 2012. Money variables are measured in constant 2021 US dollars.
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC).

Figure 3. Trends in Net Tuition: Non-Elite Sample



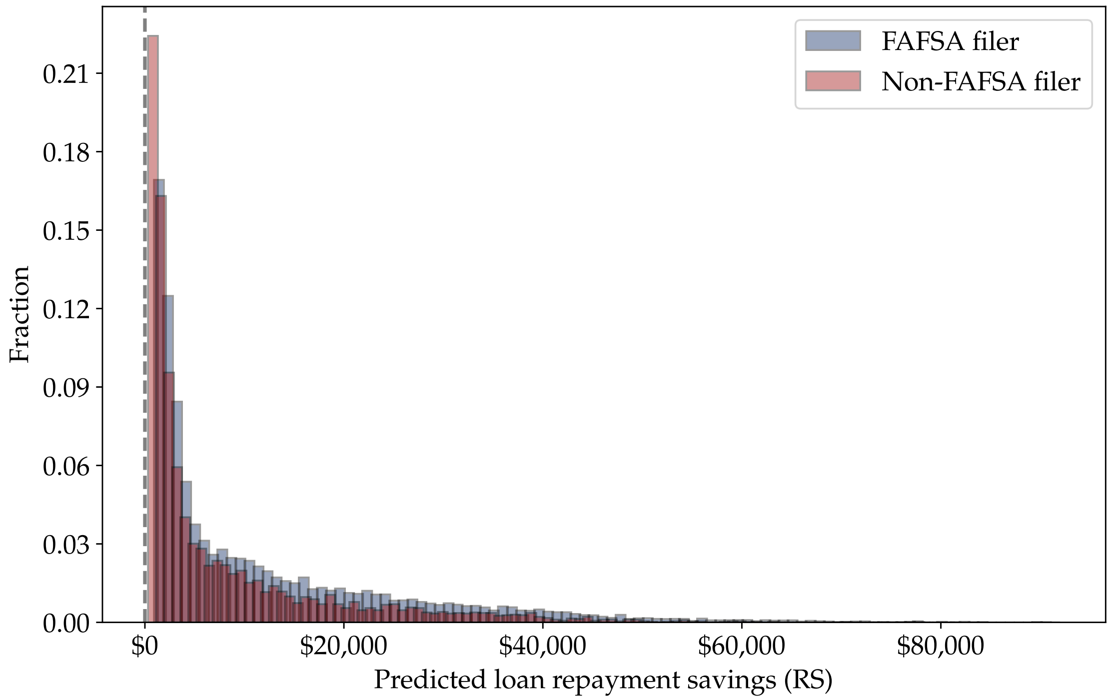
(a) Raw trends in net tuition by RS and $FAFSA$ sub-groups



(b) Net tuition differentials between RS sub-groups by $FAFSA$ status relative to academic year 2011-12

Notes: This figure plots trends in average Net Tuition as defined in subsection 4.1 by RS and $FAFSA$ sub-groups, as well as the Net Tuition differentials between RS sub-groups by $FAFSA$ filing status relative to academic year 2011-12 for non-elite sample, calculated using NPSAS survey weights. The dotted line represents the introduction of PAYE which happened in late 2012. Money variables are measured in constant 2021 US dollars.
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC).

Figure 4. Distribution of Positive Loan Repayment Savings by FAFSA Filing Status



Notes: This figure plots the distribution of positive Loan Repayment Savings (RS) as defined in Equation 7 by FAFSA filing status for overall sample, calculated using NPSAS survey weights. Numbers are measured in constant 2021 US dollars.
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC).

Figure 2b and Figure 3b show the annual net tuition differential between *RS* subgroups by FAFSA filing status, relative to the academic year 2011-12 for the elite and non-elite samples. These two figures show our two "raw" difference-in-differences trends, which correspond to the triple difference approach discussed in the next section. For the elite sample, while there was an overall decrease in net tuition among students expected to benefit from PAYE relative to those not expected to benefit from it (again, likely related to the major-specific trends discussed above), this relative decrease was more marked among non-FAFSA filers.

In summary, these figures indicate that although prices between STEM/Business and non-STEM/Business programs would be expected to diverge due to shifts in relative demand, this did *not* occur for financially aided students. We argued that this is because universities could charge higher prices to loan-dependent Arts and Humanities/Social Sciences majors facilitated by the introduction of the PAYE program.

Figure 4 further illustrates the distribution of positive *RS* for FAFSA filers and non-

FAFSA filers for the overall analysis sample, revealing significant overlap between these two sub-groups.[15] However, from the figure, it can be noted that, in comparison to FAFSA filers, non-FAFSA filers typically exhibit relatively lower RS values. These two last observations are not surprising since while non-borrowers tend to be slightly positively selected, they are not substantially different from borrowers, as the characteristics of both groups mostly reflect the overall characteristics of college goers (Looney, 2022).

4 Empirical Analysis

We follow a triple difference approach to estimate the tuition effect of the PAYE introduction in late 2012. Our design leverages student-level variation in potential loan repayment savings derived from PAYE and the fact that major-specific supply/demand shocks should equally affect both FAFSA filers and non-FAFSA filers enrolled in those majors. In this section, we begin by outlining the assumptions that underlie our research design and subsequently introduce the estimation procedures.

4.1 Identification Strategy

We use a triple difference strategy to analyze the institutions' net tuition response to the introduction of the PAYE plan. For this, it is essential to distinguish the student subgroups that, on expectation, would benefit from the policy and the subset that would not. We use the potential loan *Repayment Savings* (RS) variable we constructed using Equation 7 as our exposure variable since it is a good proxy for how much an individual student is expected to benefit from the policy. While we do not argue in favor of perfect foresight by colleges when it comes to predicting loan repayment savings, institutions have sufficient information about the potential income and borrowing behavior of their students. Additionally, we abstract from the idiosyncratic and general administrative frictions affecting initial and continued enrollment in IDR plans. We focus on identifying students with expected potential gains derived from the introduction of PAYE.

We divide students into two groups: students who are estimated to benefit from the policy (i.e., those with $RS_i > 0$) and students who are not expected to benefit from the policy (i.e., those with $RS_i = 0$). Additionally, we introduce a within RS grouping comparison using FAFSA application status to mitigate the demand/supply factors underlying trends in net tuition by majors during this period. Since the FAFSA filing information

[15] We focus on positive RS_i for exposition and illustration, as including zero RS would result in a histogram dominated by a high concentration of zeros for both FAFSA filers and non-FAFSA filers, making it difficult to observe differences in the distribution.

is observable to colleges at the time of student enrollment, it can be used as an input by colleges to engage in price discrimination (Fillmore, 2023). Therefore, under the assumption that FAFSA filers and non-FAFSA filers within RS groups experienced the same demand/supply shocks that affected the charged tuition, comparing the tuition differential between FAFSA filers and non-filers by potential PAYE beneficiary status should identify the average level change in the institution's net tuition attributable to PAYE.

The underlying identifying assumption for this triple difference design is that absent of the PAYE introduction, the relative differences in net tuition between potential PAYE beneficiaries and non-beneficiaries with observed FAFSA filing records and without FAFSA filing records would have evolved similarly. To the extent possible, we provide evidence in support of this assumption when we discuss our main results in section 5.

More formally, using the potential outcomes framework, let $Y_{it}(0)$ and $Y_{it}(1)$ denote the potential net tuition charged to student i in academic period t in a world with and without the introduction of the PAYE plan, respectively. In addition, let $FAFSA_i = 1$ denote students who filed a FAFSA application and $FAFSA_i = 0$ those who did not. Finally, let the indicator variable $Post_t$ take the value of one for the academic periods after the PAYE plan became available. Our parallel trends assumption for the triple difference strategy can be expressed as:

$$\begin{aligned}
&\Big\{\mathbb{E}[Y_{it}(0)|RS_i > 0, FAFSA_i = 1, Post_t = 1] - \mathbb{E}[Y_{it}(0)|RS_i > 0, FAFSA_i = 1, Post_t = 0]\Big\} \\
&- \Big\{\mathbb{E}[Y_{it}(0)|RS_i > 0, FAFSA_i = 0, Post_t = 1] - \mathbb{E}[Y_{it}(0)|RS_i > 0, FAFSA_i = 0, Post_t = 0]\Big\} \\
&= \Big\{\mathbb{E}[Y_{it}(0)|RS_i = 0, FAFSA_i = 1, Post_t = 1] - \mathbb{E}[Y_{it}(0)|RS_i = 0, FAFSA_i = 1, Post_t = 0]\Big\} \\
&- \Big\{\mathbb{E}[Y_{it}(0)|RS_i = 0, FAFSA_i = 0, Post_t = 1] - \mathbb{E}[Y_{it}(0)|RS_i = 0, FAFSA_i = 0, Post_t = 0]\Big\}.
\end{aligned} \tag{8}$$

Paired with a standard no-anticipation assumption,

$$\mathbb{E}[Y_{it}(0)|RS_i > 0, FAFSA_i = 1, Post_t = 0] = \mathbb{E}[Y_{it}(1)|RS_i > 0, FAFSA_i = 1, Post_t = 0], \tag{9}$$

the parallel trends assumption in Equation 8 allows us to identify the average treatment effect on the treated (ATT) in the post-period, quantifying the change in the average net tuition between the students expected to benefit and those not expected to benefit from PAYE:[16]

$$ATT = \mathbb{E}[Y_{it}(1)|RS_i > 0, FAFSA_i = 1, Post_t = 1] - \mathbb{E}[Y_{it}(0)|RS_i > 0, FAFSA_i = 1, Post_t = 1]. \tag{10}$$

[16]See Olden and Møen (2022) for a general formal derivation.

4.2 Estimation Approach

We estimate the following specification by OLS:

$$
\begin{aligned}
NetTuition_{it} = \beta &\left(RS_i^{Benefit} \times FAFSA_i \times Post_t\right) + \delta_1 \left(RS_i^{Benefit} \times FAFSA_i\right) \\
&+ \delta_2 \left(RS_i^{Benefit} \times Post_t\right) + \delta_3 \left(FAFSA_i \times Post_t\right) \\
&+ \delta_4 RS_i^{Benefit} + \delta_5 FAFSA_i + X_{it}\Gamma + \lambda_t + \lambda_{c(i)} + \varepsilon_{it},
\end{aligned}
\tag{11}
$$

where $NetTuition_{it}$ is the annual net tuition charged to student i in academic year t. We also estimate the effect on sticker price tuition and institutional aid by replacing $NetTuition_{it}$ with $StickerPrice_{it}$ and $InstiAid_{it}$, respectively. $RS_i^{Benefit} = \mathbb{1}\left[RS_i > 0\right]$ is a dummy variable indicating whether a student is potentially going to save in loan repayments by participating in PAYE or not; $FAFSA_i$ is a dummy variable indicating whether a student filed for FAFSA during her undergraduate enrollment or not; and $Post_t$ is an indicator variable equal to 1 if the academic year is after 2012, which in our case would be years 2015-16 and 2017-18, and 0 otherwise. X_{it} is a vector of student characteristics, including gender, race/ethnicity, SAT score, attendance pattern (full-time or part-time), dependency status, income level, an interaction term between dependency status and income (since in NPSAS the income variable is defined as parents' income if the student is dependent, and student's income if the student is independent), a dummy variable indicating which year they are in college, and a dummy variable indicating if the student is from out-of-state or in-state. In Equation 11, we also include the three two-way interactions between $RS_i^{Benefit}$, $FAFSA_i$, and $Post_t$, as well as the single indicators for $RS_i^{Benefit}$ and $FAFSA_i$. Table 2 presents the summary statistics for student characteristics X_{it} as well as the distribution of different institution types. Finally, λ_t are year fixed effects, $\lambda_{c(i)}$ are college fixed effects, and ε_{it} is an error term.

The parameter of interest is β, which is the average institutional net tuition response in dollar amount due to the introduction of the PAYE plan. The reported standard errors are clustered at the institution level. We run the regression on the overall sample and also separately for the elite and non-elite samples of institutions as defined in subsection 3.3. For all of our regressions, we weight each observation using the sample weights provided in the NPSAS data.

To shed light on the dynamics of the response and evaluate the plausibility of the parallel trends assumption, we also implement the triple difference design with an event-

Table 2. Summary Statistics of Student Characteristics

	Elite Sample	Non-elite Sample	All
Gender (%)			
Male	45.38	45.77	45.61
Female	54.62	54.23	54.39
Race/Ethnicity (%)			
White	64.25	64.40	64.34
Black	11.79	12.26	12.07
Hispanic	10.56	12.80	12.43
Asian	8.63	6.23	7.34
Other	4.70	4.79	4.75
Which year in college (%)			
1st year undergraduate	21.87	21.46	21.62
2nd year undergraduate	20.28	19.56	19.85
3rd year undergraduate	22.05	21.52	21.73
4th year undergraduate	30.97	32.09	31.64
5th year undergraduate	3.75	4.41	4.14
Unclassified undergraduate	1.08	0.97	1.01
College attendance pattern (%)			
Exclusively full-time	68.47	58.61	62.57
Exclusively part-time	13.62	19.86	17.35
Mixed full-time and part-time	17.91	21.53	20.08
Attend institution in state of residence (%)			
Yes	70.11	89.60	81.77
No	29.89	10.40	18.23
Student dependency status (%)			
Dependent student	70.11	89.60	81.77
Independent student	29.89	10.40	18.23
SAT score	1,114.89	1,023.13	1,060.26
	(197.38)	(175.92)	(190.31)
Family income	105,348.02	84,912.54	93,180.57
	(106,717.83)	(82,504.77)	(93,602.03)
% of private non-profit institutions	57.44	0.00	23.08
% of Top 100 institutions	40.70	6.42	20.19

Notes: This table presents the descriptive statistics of the student characteristics, which correspond to the X_{it} in Equation 11. Means and standard deviations are calculated for continuous variables, and distributional shares (%) are calculated for categorical variables using NPSAS survey weights. Columns 1, 2, and 3 report the statistics among the elite sample, non-elite sample, and pooled overall sample, respectively. Money variables are measured in constant 2021 US dollars.
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

study specification that we also estimate by OLS. Specifically, we run the regression:

$$\begin{aligned}
NetTuition_{it} = {} & RS_i^{Benefit} \times FAFSA_i \times \sum_{\substack{\tau=2003\text{-}04 \\ \tau\neq 2011\text{-}12}}^{2017\text{-}18} \beta_\tau \mathbb{1}[t=\tau] + FAFSA_i \times \sum_{\substack{\tau=2003\text{-}04 \\ \tau\neq 2011\text{-}12}}^{2017\text{-}18} \delta_{1,\tau} \mathbb{1}[t=\tau] \\
& + RS_i^{Benefit} \times \sum_{\substack{\tau=2003\text{-}04 \\ \tau\neq 2011\text{-}12}}^{2017\text{-}18} \delta_{2,\tau} \mathbb{1}[t=\tau] + \delta_3 \left(RS_i^{Benefit} \times FAFSA_i \right) \\
& + \delta_4 RS_i^{Benefit} + \delta_5 FAFSA_i + X_{it}\Gamma + \lambda_t + \lambda_{c(i)} + \varepsilon_{it},
\end{aligned} \tag{12}$$

where $\beta_{\tau,t>2011\text{-}12}$ represents the average tuition response at time $t = \tau$ after the introduction of the PAYE, and everything else is defined as in Equation 11. Similarly, we also run the same specification for $StickerPrice_{it}$ and $InstiAid_{it}$.

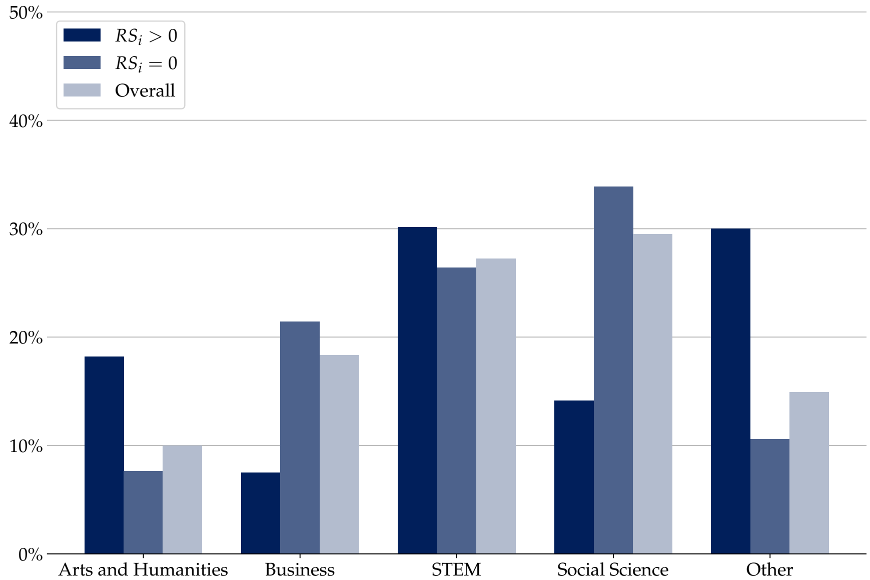
5 Results

In this section, we report and discuss our analysis results. First, we investigate the plausibility of adopting RS as our treatment variable by characterizing the sub-groups with $RS > 0$ and $RS = 0$. We then report and discuss our main triple difference estimates of the net tuition response to the PAYE plan introduction for the elite, non-elite, and overall samples. Finally, we present the sticker-price tuition and institutional aid results to identify the driving factors behind the net tuition response.

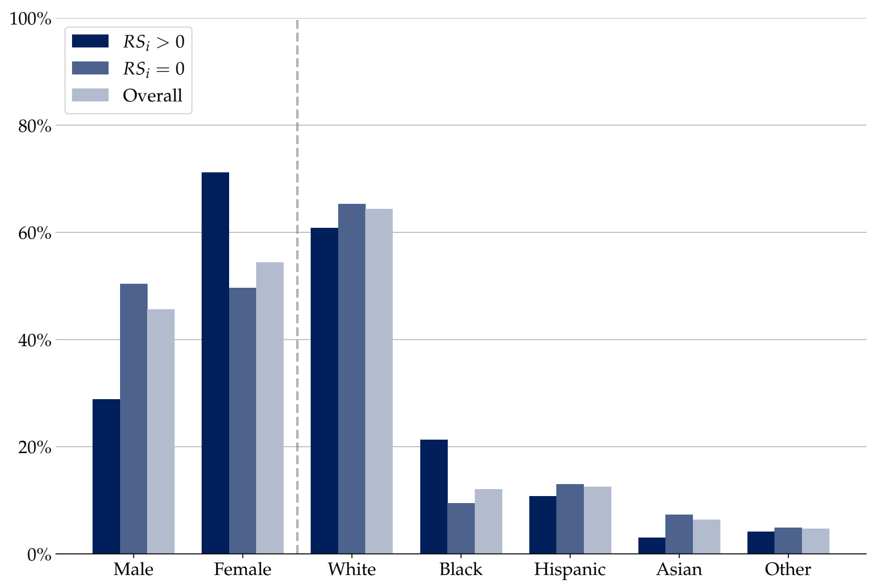
5.1 The Plausibility of Adopting RS as Treatment Variable

To assess whether RS is a good indicator for capturing the potential loan repayment savings variation introduced by PAYE, we divide our overall sample into sub-groups with $RS = 0$ and $RS > 0$, which maps the sub-groups of students who are not projected to benefit from the PAYE policy, and the potential PAYE beneficiaries. We compare the characteristics of both sub-groups and also present numbers for the overall sample to benchmark compositional patterns.

Figure 5. Distribution of Students Potentially Benefiting From PAYE by Major Category, Sex, and Race/Ethnicity



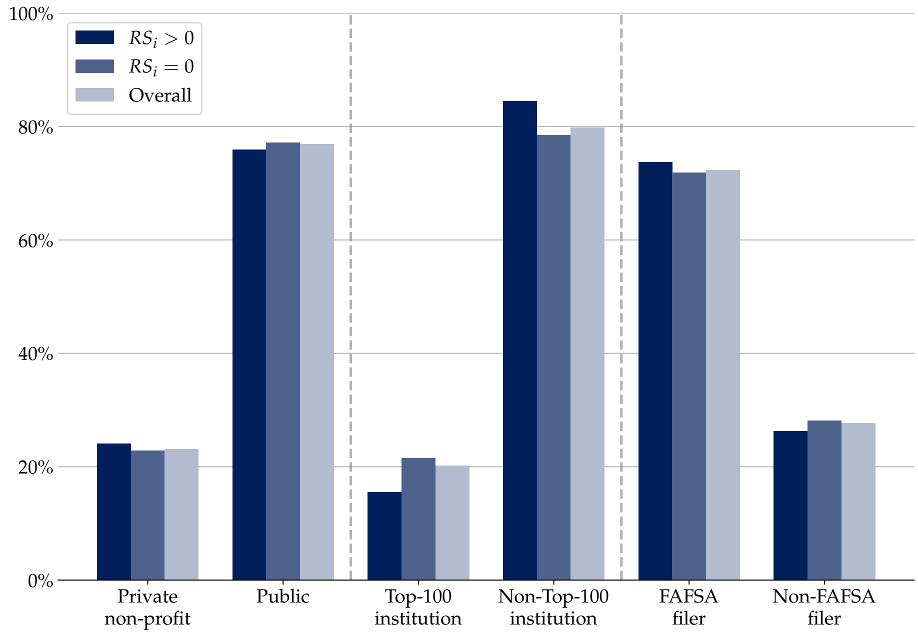
(a) Distribution by major category



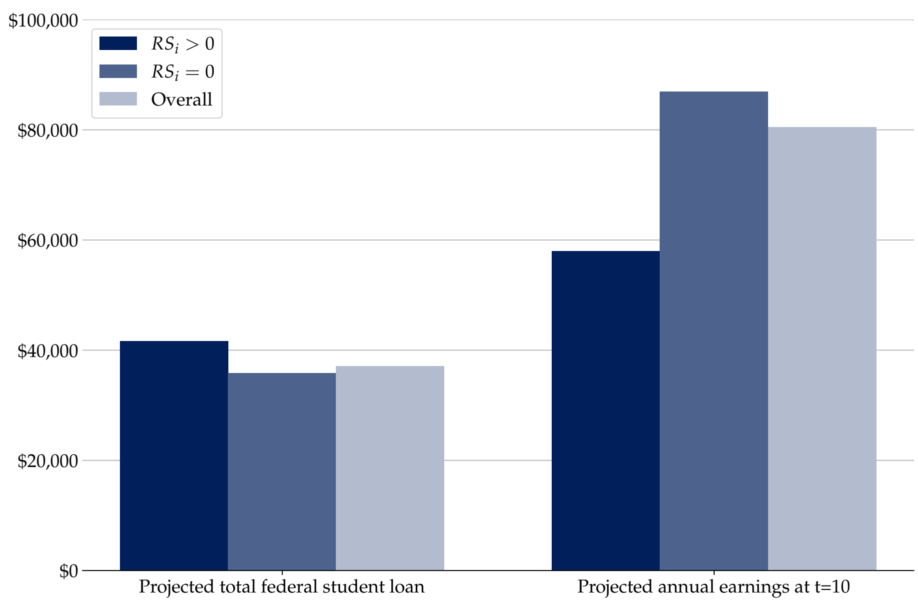
(b) Distribution by sex and race/ethnicity

Notes: This figure plots the distribution of sub-groups with $RS_i > 0$ and $RS = 0$ and overall sample by major category, sex, and race/ethnicity. NPSAS sample weights are used for calculation.
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

Figure 6. Distribution of Students Potentially Benefiting from PAYE by Institution Type, FAFSA filing status, and Projected Average Federal Student Loan Amount and Income at $t = 10$



(a) Distribution by institution type and FAFSA filing status



(b) Projected federal student loan and income

Notes: This figure plots the distribution of sub-groups with $RS_i > 0$ and $RS_i = 0$ and overall sample by institution type, as well as the means of the same sample groups on projected total federal student loan and annual income at year 10 after college graduation. NPSAS sample weights are used for calculation. Money variables are measured in constant 2021 US dollars.
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

Figure 5a presents the distribution of students potentially benefiting from PAYE by undergraduate major category. Compared with students with $RS = 0$ (students who are potentially not going to benefit from the PAYE policy), students with $RS > 0$ have a larger share of concentration in majors such as Arts and Humanities (18% vs. 8%) and Social Science (30% vs. 11%), and a lower concentration in majors such as Business (8% vs. 21%) and STEM (14% vs. 34%). This pattern mirrors the results presented by Kirkeboen et al. (2016) and Webber (2014) since the students with majors in Arts and Humanities and Social Sciences tend to have lower earnings compared to STEM or Business majors (in Figure A1, we showed the average simulated income trajectories for these majors); therefore, *ceteris paribus*, they are more likely to be beneficiaries of the IDR plans.

Next, Figure 5b presents the distribution of students potentially benefiting from PAYE by sex and race/ethnicity. Students with $RS > 0$ are more likely to be female (71% vs. 50%) and Black (21% vs. 9%). This distribution pattern mirrors the findings documented in Catherine and Yannelis (2023), which show that targeted IDR plans progressively benefit racial and ethnic minority groups.

Figure 6a shows the distribution of students potentially benefiting from PAYE by institution type and FAFSA filing status. The share of students coming from either private non-profit or public institutions is very similar, indicating that institutional control is not highly correlated with the projected loan repayment savings outcomes. PAYE potential beneficiaries are more concentrated in non-Top-100 institutions (84% vs. 78%) because students at these institutions tend to have lower expected future income. Additionally, PAYE potential beneficiaries are slightly more likely to be FAFSA filers (74% vs. 72%).

Figure 6b shows the average projected total federal student loan and the average projected annual earnings at $t = 10$ after college completion for both sub-groups as well as the overall sample. The PAYE beneficiary sub-group has substantially larger total federal student loans ($41,589 vs. $35,813) and lower average annual earnings ($57,947 vs. $86,942). These findings echo the results in Karamcheva et al. 2020 (see Figure 3-1), indicating that IDR plans tend to benefit student borrowers with lower projected incomes and higher student loan amounts.

Finally, we also demonstrate the effect of PAYE on outcomes that are more likely to be directly affected by its introduction. Table 3 shows the simple difference-in-differences estimates on observed student borrowing choices and the amount they cumulatively borrowed for their undergraduate study at the point of NPSAS data collection, with the same set of controls stated in Equation 11. The coefficient in column 1 of Table 3 implies that students who expect to benefit from PAYE are about 2.3 percentage points more likely to borrow for their studies post-policy change compared to students who do not expect to

Table 3. Summary Difference-in-Differences Estimates for Related Outcome

	Whether borrowed for undergraduate study (1)	Amount ($) borrowed (all students) (2)	Amount ($) borrowed (only borrowers) (3)
$RS^{Benefit} \times Post$	0.023**	2,305.46***	1,506.85***
	(0.011)	(341.922)	(318.834)
N of Observations	166,540	166,540	100,520
N of Institutions	860	860	860

Notes: Columns 1, 2, and 3 report the summary difference-in-differences estimates on the federal student loan borrowing decision (0/1), the amount borrowed for undergraduate study on overall sample, and the amount borrowed for undergraduate study only on borrowers sample, respectively. NPSAS sample weights are used for all estimates. Money variables are measured in constant 2021 US dollars. N of observations and institutions are rounded to the nearest 10 per IES restricted-use guidelines. Standard errors are clustered at the institution level and presented in parentheses (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$).
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

benefit from PAYE.[17] Columns 2 and 3 show the average effect of PAYE on the amount of federal student loan borrowing, reflecting how much more PAYE beneficiaries borrow relative to non-beneficiaries after its introduction. On average, we find that PAYE induces students to borrow an additional $2,305. Among those who borrow, students expected to benefit from PAYE experience a marginal borrowing increase of $1,507.

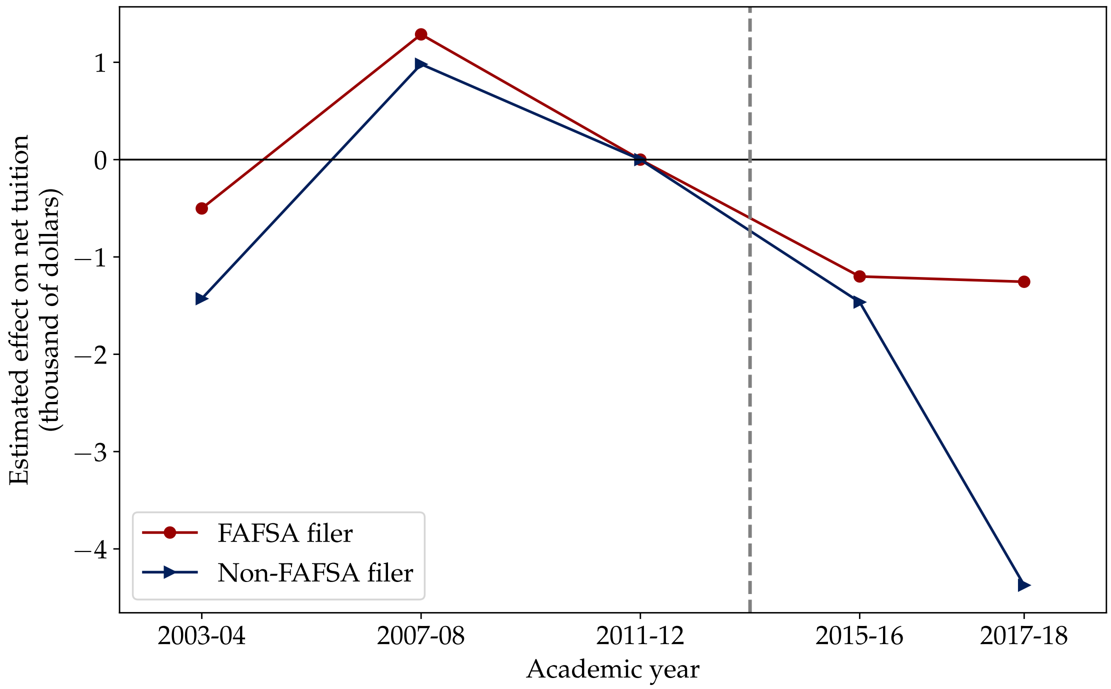
5.2 Triple Difference Analysis

We first investigate the trends in net tuition differentials between potential PAYE beneficiaries and non-beneficiaries separately for FAFSA filers and non-FAFSA filers by running a simple difference-in-differences regression on each of these samples. Figure 7 plots these results for the elite sample.[18] The plot shows that, since 2007-08, there has been a decreasing trend in the net tuition differentials for both FAFSA filers and non-FAFSA filers, which we argue is related to the supply and demand factors we discussed earlier in section 4 that differentially affected the majors PAYE beneficiaries and non-beneficiaries disproportionally tend to come from. However, after the introduction of PAYE, especially in the academic year 2017-18, the trends begin to diverge between FAFSA filers

[17] For the pre-period sample, the average borrowing rate is 63% for the $RS > 0$ sub-group, and 61% for the $RS = 0$ sub-group, indicating only minor difference in borrowing behavior between the treatment and comparison groups.

[18] We focus on the event study for the elite sample here for expositional reasons, as the results are most pronounced in this group rather than in the overall or non-elite samples.

Figure 7. Trends in Net Tuition Differentials Between PAYE Beneficiaries and Non-Beneficiaries, by FAFSA Filing Status: Elite Sample

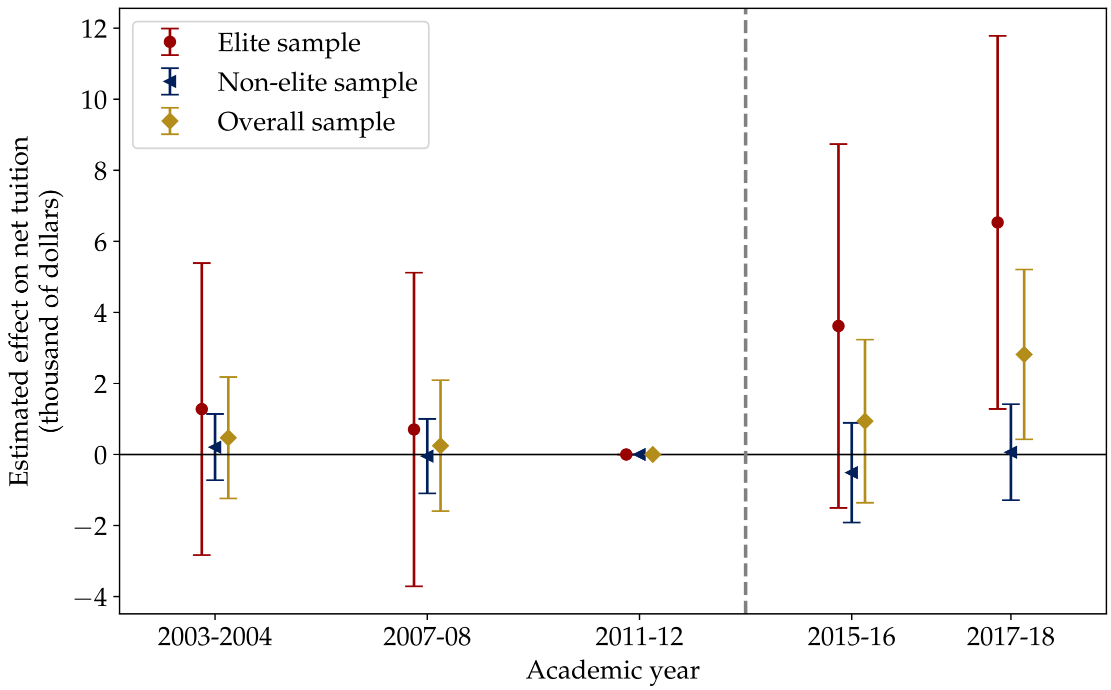


Notes: This figure plots trends in the differentials of NetTuition$_{it}$ between sub-groups of FAFSA filers and non-FAFSA filers for elite sample institutions as defined in subsection 4.2. The dots and triangles represent the estimated difference-in-differences coefficients. All estimates are weighted by the NPSAS data set sample weights.
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

and non-FAFSA filers. The trend for FAFSA filers flattens but continues to decrease for non-FAFSA filers. Our triple difference design assumes that the trend in net tuition differentials among FAFSA filers would have looked like the one for non-filers in the absence of PAYE.

Figure 8 plots the event-study estimates of β_τ from the triple difference specification in Equation 12 that compares annual net tuition response across students with different PAYE benefiting potentials and FAFSA filing status, before and after the introduction of the PAYE plan for elite, non-elite, and the overall samples. None of the coefficients in academic years 2003-04 and 2007-08 is statistically significant at the 5 percent level, supporting the parallel trends assumption underlying the triple difference design. Additionally, we tested pre-period trends by estimating the triple difference specification in Equation 12 using only pre-PAYE observations and conducted a joint test of these coeffi-

Figure 8. Triple Difference Event-Study Estimates: Net Tuition



Notes: This figure plots the estimates of β_τ of NetTuition_{it} in Equation 12 for elite sample, non-elite sample, and overall sample institutions as defined in subsection 4.2. The dots, triangles, and squares represent the estimated coefficients and the vertical bars represent the 95 percent confidence intervals. All estimates are weighted by the NPSAS data set sample weights. Standard errors are clustered at the institution level.
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

cients. With the pre-trend tests p-values of 0.66, 0.97, and 0.88, we conclude that there is no statistical evidence of pre-trends in our setting.

The post-period estimates after the introduction of PAYE in late 2012 reflect an increase in net tuition for the elite and overall samples of institutions. Table 4 shows the triple difference estimates of the treatment effect on annual net tuition for the elite, non-elite, and overall sample, using Equation 11 and Equation 12. Column 1 of panel A presents the summary triple difference estimate for the elite sample, which implies that, among elite sample institutions, students who are estimated to benefit from PAYE saw an average level increase of annual net tuition price of \$3,598, compared to students who are estimated not to benefit. The semi-elasticity estimate can be constructed by

$$\frac{\hat{\beta}}{\mu_{RS^{Benefit}=1,FAFSA_i=1} - \mu_{RS^{Benefit}=0,FAFSA_i=1}} = \frac{\hat{\beta}}{\mu_{RS^{Benefit}=1,FAFSA_i=1}}, \tag{13}$$

where $\mu_{RS^{Benefit}=1,FAFSA_i=1}$ and $\mu_{RS^{Benefit}=0,FAFSA_i=1}$ are the average loan repayment savings (RS) for these two sub-groups.[19] The semi-elasticity equals 42.31%, which implies that for every additional \$100 in lifetime loan repayment savings for a PAYE beneficiary, the institutions responded by increasing the net tuition by about \$42.31, relative to students who are not going to benefit from the PAYE policy. Column 1 of panel B from Table 4 reports the estimated annual net tuition effect by academic year, using academic year 2011-12 as the reference. The effect is mostly driven by the response in academic year 2017-18, implying some potential delay in institutions' response.

Columns 2 of panels A and B in Table 4 present the estimated summary annual net tuition effect and the yearly response to PAYE, respectively, for the non-elite sample institutions. We observe no statistically significant coefficients, and the magnitudes of these estimates are substantially smaller than those for the elite sample. These results support our initial assumption that, compared to elite institutions, non-elite public institutions generally have less discretionary power over tuition pricing. Additionally, public institutions often face greater social and political pressure to maintain affordable tuition, employing strategies such as tuition cuts and freezes.

Similarly, columns 3 of panels A and B in Table 4 report the summary annual net tuition effect and the event study estimates for the overall sample. Pooling all of the private non-profit and public four-year institutions, we observe an average increase in net tuition of \$1,525 for students who are estimated to benefit from PAYE. The comparable

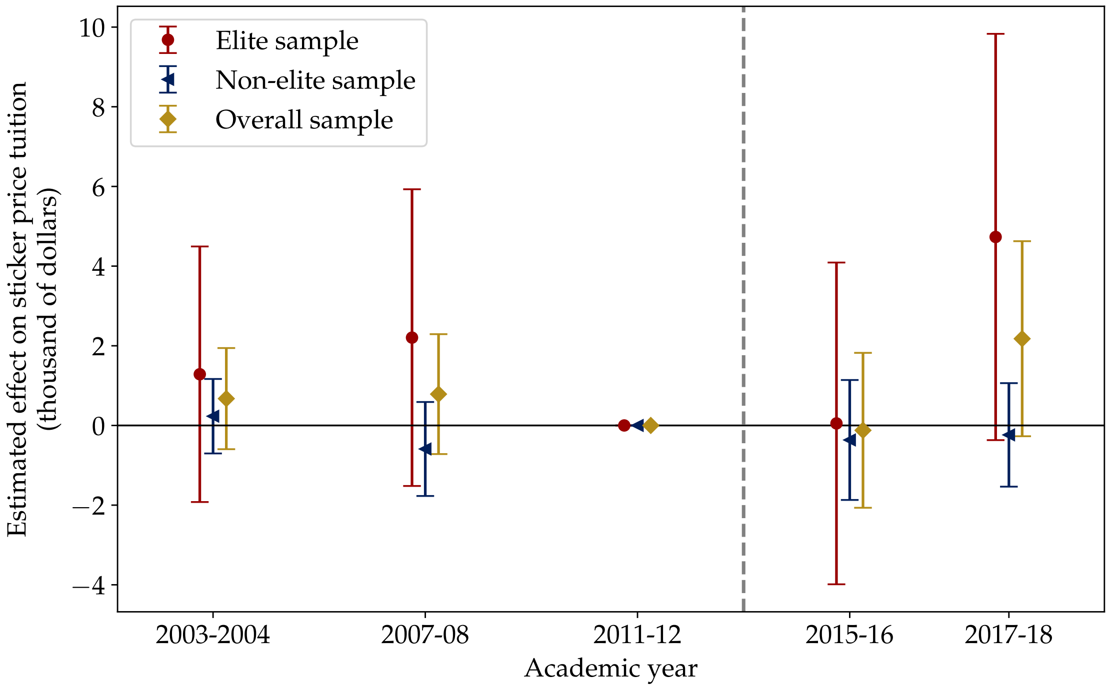
[19] According to the data, $\mu_{RS^{Benefit}=1,FAFSA_i=1}$ equals 8.504 and $\mu_{RS^{Benefit}=0,FAFSA_i=1}$ equals 0, measured in thousand of 2021 constant dollars.

Table 4. Summary Triple Difference Estimates for Net Tuition

	Net tuition (thousand of dollars)		
	Elite sample (1)	Non-elite sample (2)	Overall sample (3)
Panel A. Pre-Post analysis			
$RS_i^{Benefit} \times FAFSA_i \times Post$	3.598***	-0.127	1.525***
	(1.191)	(0.419)	(0.578)
Panel B. Event study analysis			
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = 2003\text{-}04]$	1.277	0.206	0.470
	(2.097)	(0.475)	(0.871)
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = 2007\text{-}08]$	0.704	-0.047	0.246
	(2.253)	(0.535)	(0.940)
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = 2011\text{-}12]$	[Reference]	[Reference]	[Reference]
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = 2015\text{-}16]$	3.616	-0.511	0.938
	(2.614)	(0.716)	(1.171)
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = 2017\text{-}18]$	6.531**	0.062	2.816**
	(2.680)	(0.689)	(1.220)
Pre-trends test p-value	0.66	0.97	0.88
N of Observations	67,880	98,660	166,540
N of Institutions	520	340	860

Notes: This table presents summary triple difference estimates of NetTuition_{it} using Equation 11 and Equation 12. Columns 1, 2, and 3 report the estimates on the elite sample, non-elite sample, and overall sample, respectively. Panel A reports the estimates using Equation 11, and panel B reports the estimates using Equation 12. NPSAS sample weights are used for all estimates. The pre-trends test p-value come from a joint test of the pre-period placebo effects conducted using only pre-PAYE observations. N of observations and institutions are rounded to the nearest 10 per IES restricted-use guidelines. Standard errors are clustered at the institution level and presented in parentheses (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$).
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

Figure 9. Triple Difference Event-Study Estimates: Sticker Price Tuition



Notes: This figure plots the estimates of β_τ of StickerPrice_{it} in Equation 12 for elite sample, non-elite sample, and overall sample institutions as defined in subsection 4.2. The dots, triangles, and squares represent the estimated coefficients and the vertical bars represent the 95 percent confidence intervals. All estimates are weighted by the NPSAS data set sample weights. Standard errors are clustered at the institution level.
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

pass-through effect is 19.12%.[20]

Since $\text{NetTuition}_{it} = \text{StickerPrice}_{it} - \text{InstiAid}_{it}$ as defined in subsection 3.2, we then explore the two contributing factors behind the annual net tuition response by replacing NetTuition_{it} with StickerPrice_{it} and InstiAid_{it} in Equation 11 and Equation 12.

Figure 9 plots the event-study estimates of β_τ for StickerPrice_{it}. Table 5 reports the summary triple difference and even-study estimates. Intuitively, we do not observe any statistically significant sticker price tuition effect due to the introduction of PAYE since, theoretically, the potential PAYE beneficiaries and non-beneficiaries should face the same sticker price tuition (conditional on the college fixed effects and other controls), and institutions usually conduct tuition price discounting by modifying institutional aid amount

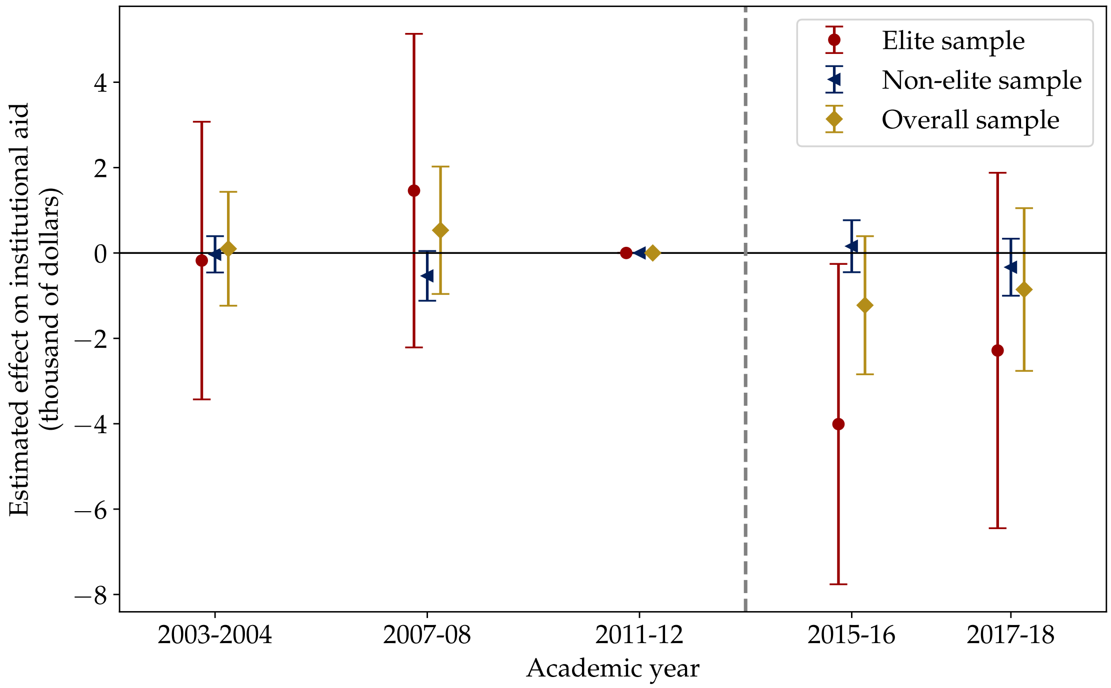
[20]According to the data, $\mu_{RS^{Benefit}=1,FAFSA_i=1}$ equals 7.977 and $\mu_{RS^{Benefit}=0,FAFSA_i=1}$ equals 0, measured in thousand of 2021 constant dollars. The semi-elasticity is calculated as $\hat{\beta}/(\mu_{RS^{Benefit}=1,FAFSA_i=1} - \mu_{RS^{Benefit}=0,FAFSA_i=1})$, which is therefore $1.525/((7.977 - 0)) = 19.12\%$.

Table 5. Summary Triple Difference Estimates for Sticker Price Tuition

	Sticker price tuition (thousand of dollars)		
	Elite sample (1)	Non-elite sample (2)	Overall sample (3)
Panel A. Pre-Post analysis			
$RS_i^{Benefit} \times FAFSA_i \times Post$	1.017	0.209	0.862
	(1.363)	(0.422)	(0.722)
Panel B. Event study analysis			
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = \text{2003-04}]$	1.285	0.232	0.674
	(1.636)	(0.477)	(0.648)
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = \text{2007-08}]$	1.205	-0.591	0.787
	(1.900)	(0.602)	(0.768)
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = \text{2011-12}]$	[Reference]	[Reference]	[Reference]
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = \text{2015-16}]$	0.051	-0.365	-0.122
	(2.060)	(0.768)	(0.992)
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = \text{2017-18}]$	4.731*	-0.237	2.178*
	(2.602)	(0.663)	(1.249)
Pre-trends test p-value	0.65	0.22	0.87
N of Observations	67,880	98,660	166,540
N of Institutions	520	340	860

Notes: This table presents summary triple difference estimates of StickerPrice$_{it}$ using Equation 11 and Equation 12. Columns 1, 2, and 3 report the estimates on the elite sample, non-elite sample, and overall sample, respectively. Panel A reports the estimates using Equation 11, and panel B reports the estimates using Equation 12. NPSAS sample weights are used for all estimates. The pre-trends test p-value come from a joint test of the pre-period placebo effects conducted using only pre-PAYE observations. N of observations and institutions are rounded to the nearest 10 per IES restricted-use guidelines. Standard errors are clustered at the institution level and presented in parentheses (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$).
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

Figure 10. Triple Difference Event-Study Estimates: Institutional Aid



Notes: This figure plots the estimates of β_τ of InstiAid_{it} in Equation 12 for elite sample, non-elite sample, and overall sample institutions as defined in subsection 4.2. The dots, triangles, and squares represent the estimated coefficients and the vertical bars represent the 95 percent confidence intervals. All estimates are weighted by the NPSAS data set sample weights. Standard errors are clustered at the institution level.
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

(Fillmore, 2023).

Figure 10 plots the event-study estimates of β_τ for InstiAid_{it}. Table 6 documents the triple difference estimates for the institutional aid effect. We observe a statistically significant level decrease of $2,875 for elite sample institutions. Not surprisingly, the non-elite sample did not show a significant effect due to PAYE, as well as the overall sample, which serves as evidence that price discounting is mainly a phenomenon of elite colleges.

6 Robustness

In this section, we conduct various analyses to assess the robustness of our findings. We start by addressing the endogeneity concern of the *FAFSA* filing status by replacing the observed status with a predicted *FAFSA* filing status derived from a model estimated using only pre-period data. Next, we revise the definitions of our elite and non-elite

Table 6. Summary Triple Difference Estimates for Institutional Aid

	Institutional Aid (thousand of dollars)		
	Elite sample (1)	Non-elite sample (2)	Overall sample (3)
Panel A. Pre-Post analysis			
$RS_i^{Benefit} \times FAFSA_i \times Post$	-2.875**	0.370	-0.760
	(1.285)	(0.215)	(0.683)
Panel B. Event study analysis			
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = \text{2003-04}]$	-0.178	-0.032	0.099
	(1.659)	(0.217)	(0.681)
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = \text{2007-08}]$	1.461	-0.536*	0.532
	(1.874)	(0.297)	(0.761)
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = \text{2011-12}]$	[Reference]	[Reference]	[Reference]
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = \text{2015-16}]$	-4.009**	0.158	-1.224
	(1.915)	(0.311)	(0.825)
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = \text{2017-18}]$	-2.284	-0.333	-0.856
	(2.124)	(0.341)	(0.973)
Pre-trends test p-value	0.24	0.13	0.62
N of Observations	67,880	98,660	166,540
N of Institutions	520	340	860

Notes: This table presents summary triple difference estimates of InstiAid$_{it}$ using Equation 11 and Equation 12. Columns 1, 2, and 3 report the estimates on the elite sample, non-elite sample, and overall sample, respectively. Panel A reports the estimates using Equation 11, and panel B reports the estimates using Equation 12. NPSAS sample weights are used for all estimates. The pre-trends test p-value come from a joint test of the pre-period placebo effects conducted using only pre-PAYE observations. N of observations and institutions are rounded to the nearest 10 per IES restricted-use guidelines. Standard errors are clustered at the institution level and presented in parentheses (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$).
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

samples to verify the robustness of our results. Additionally, we assess the robustness of the adoption of the treatment variable by using the continuous variable RS instead of the discrete sub-groups defined by $RS^{Benefit} = \mathbb{1}[RS > 0]$.

6.1 Replacing FAFSA with Predicted FAFSA Status

One potential concern about using the FAFSA filing status in our strategy is that this could be endogenous, as the introduction of PAYE could also influence the choice of filing for FAFSA in a way that alters the composition of the groups after the policy change. In order to address this concern, we replace the post-period $FAFSA$ status with a predicted FAFSA status variable, $FAFSA^{pred}$. Specifically, using only pre-period observations, we run the following logistic regression:

$$Pr(FAFSA_i = 1) = \frac{\exp(X_i\Pi + Z_{c(i)}\Gamma)}{1 + \exp(X_i\Pi + Z_{c(i)}\Gamma)}, \tag{14}$$

with the same right-hand-side specification as in Equation 3, since we believe the set of students' characteristics we include for predicting student loan amounts are similarly likely to influence the choice of applying for financial aid. We then use the fitted model to predict the choice of filing for FAFSA for the post-period sample.[21] After obtaining the post-period predicted FAFSA status, we run Equation 11 and Equation 12, replacing $FAFSA_i$ with $FAFSA_i^{pred}$.

Figure A3 plots the event-study estimates of Equation 12 with the replacement of $FAFSA_i^{pred}$ for elite, non-elite, and overall sample. Table A3 presents the summary triple difference and the event-study on NetTuition$_{it}$. The reported results are generally consistent with the main analysis, with the exception that the non-elite sample institutions also exhibit a statistically significant net tuition effect of \$1,626, implying a possibility of PAYE's impact on less-selective public institutions. Additionally, the elite sample now shows a net tuition increase of \$2,183, significant at the 10% level, roughly 40% lower than what we observed in the main analysis. Overall, the private and public four-year institutions show an increase of net tuition of \$1,765 due to the introduction of PAYE. With this method, the comparable pass-through effects for elite, non-elite, and overall samples are 26%, 22%, and 23%, respectively.

[21] After using the fitted logistic regression coefficients to predict the FAFSA choice on the post-period sample, we obtain a probability of filing for FAFSA for each student. We then calibrate the threshold of assigning zero/one based on the predicted probability to match the overall pre-period FAFSA filing ratio, which is about 0.71.

6.2 Alternative Elite and Non-Elite Sample Definition

In section 4, following Fillmore (2023), we divided our analysis sample into elite and non-elite subsets in our main analysis. Specifically, we defined our elite sample as all private non-profit four-year institutions and public four-year institutions with selectivity classified as "very selective." The non-elite sample comprised the remaining public four-year institutions with selectivity classified as "moderately selective," "minimally selective," and "open admission." Here, we explore another way of defining elite and non-elite samples to assess our results' robustness.

Specifically, to construct the elite sample, we first include all private non-profit four-year institutions, but instead of using "very selective" public four-year institutions, we choose public institutions that ranked Top 100 at least half of the time between 2008 and 2018 in the U.S. News Rankings. The alternative non-elite sample contains the remaining public four-year institutions outside of the Top 100 ranking. The alternative elite sample is made of 480 unique institutions, whereas the alternative non-elite contains 370 unique institutions.[22]

Figure A4 plots the event-study estimates of Equation 12 using this alternative definition of the elite and non-elite samples. Neither of the pre-period coefficients is significant, but after the introduction of PAYE, tuition among the elite sample institutions substantially increased. Table A4 reports the triple difference and the event-study estimates of NetTuition_{it} implemented on the alternative elite and non-elite samples. Among elite sample institutions, we observe a level increase of \$3,931 due to PAYE, which translates to an about 46% pass-through effect.[23] Similarly to our main results, the effect showed up more prominently in the academic year 2017-18. As for the non-elite sample, the results point to a statistically insignificant and negligible tuition effect due to the introduction of PAYE.

6.3 Alternative Continuous Treatment Variable

To assess the robustness of the adoption of RS as the treatment variable, as well as to explore the marginal effect of the net tuition increase, we also run an additional regression similar to Equation 11, but replace the categorical dummy variable $RS^{Benefit}$ with the continuous RS. This approach allows us to exploit the full variation in our simulated

[22]The number of observations and institutions are rounded to the nearest 10 per IES restricted-use guidelines.

[23]The pass-through effect is calculated as $\hat{\beta}/(\mu_{RS_i^{Benefit}=1,FAFSA_i=1} - \mu_{RS_i^{Benefit}=0,FAFSA_i=1})$, where $\mu_{RS_i^{Benefit}=1,FAFSA_i=1}$ is 8.553, and $\mu_{RS_i^{Benefit}=0,FAFSA_i=1}$ is 0, measured in thousand of 2021 constant dollars.

PAYE-derived repayment savings. Specifically, we estimate:

$$\begin{aligned} NetTuition_{it} &= \beta\left(RS_i \times FAFSA_i \times Post_t\right) + \delta_1\left(RS_i \times FAFSA_i\right) \\ &\quad + \delta_2\left(RS_i \times Post_t\right) + \delta_3\left(FAFSA_i \times Post_t\right) \\ &\quad + \delta_4 RS_i + \delta_5 FAFSA_i + X_{it}\Gamma + \lambda_t + \lambda_{c(i)} + \varepsilon_{it}. \end{aligned} \tag{15}$$

Therefore, the β directly captures the marginal change in the institution's net tuition per lifetime loan repayment savings instead of the average level comparison measured in Equation 11.

Similarly, we examine the event-study specification to evaluate the parallel trends assumption, with all other terms remaining the same as Equation 12:

$$\begin{aligned} NetTuition_{it} = RS_i \times FAFSA_i \times \sum_{\substack{\tau=2003\text{-}04 \\ \tau\neq 2011\text{-}12}}^{2017\text{-}18} \beta_\tau \mathbb{1}[t=\tau] + FAFSA_i \times \sum_{\substack{\tau=2003\text{-}04 \\ \tau\neq 2011\text{-}12}}^{2017\text{-}18} \delta_{1,\tau} \mathbb{1}[t=\tau] \\ + RS_i \times \sum_{\substack{\tau=2003\text{-}04 \\ \tau\neq 2011\text{-}12}}^{2017\text{-}18} \delta_{2,\tau} \mathbb{1}[t=\tau] + \delta_3\left(RS_i \times FAFSA_i\right) \\ + \delta_4 RS_i + \delta_5 FAFSA_i + X_{it}\Gamma + \lambda_t + \lambda_{c(i)} + \varepsilon_{it}. \end{aligned} \tag{16}$$

We plot the event-study (Equation 16) estimates in Figure A5 and report the triple difference estimates of Equation 15 and Equation 16 for elite, non-elite, and overall samples in Table A5. As shown in the figure and table, the main patterns of our findings remain.

Among elite sample institutions, we observe an increase of \$14.48 of annual net tuition per \$100 lifetime student loan payment savings. Similarly, we observe an increase of \$6.67 of annual net tuition per \$100 lifetime student loan payments savings for the overall sample, about half the size of the elite sample. The estimated pass-through effects for these two groups are smaller than those presented in the main results of the previous section, indicating potential non-linearity in the effect on net tuition. For non-elite sample institutions, we do not observe a statistically significant effect, and the magnitude of the effect is comparably small.

7 Conclusion and Discussion

In our analysis, we examined the net tuition response to the introduction of the PAYE plan in late 2012. We argued that the increased generosity from the IDR plan introduced incentives for institutions participating in Title IV programs to capture part of these new implicit subsidies, in line with the well-known Bennett hypothesis. Among elite institutions, which, following Fillmore (2023), we define as all four-year private non-profit institutions and "very selective" four-year public institutions, we documented a pass-through effect of about 42.31% on net tuition. This means that for every $100 in potential lifetime savings from PAYE, the institution responds by increasing net tuition by an average of $42. This net tuition effect is primarily driven by a decrease in institutional aid rather than an increase in the tuition sticker price. Among non-elite institutions — mostly public, less selective colleges — we find a statistically insignificant and economically negligible overall pass-through effect. When pooling elite and non-elite institutions together, we observe a statistically significant pass-through effect of roughly 19.12%, which is less than half of the pass-through effect seen in elite institutions.

We support our primary findings through several robustness checks, demonstrating that these patterns are not sensitive to whether using observed or predicted FAFSA filing status as a within-subgroup comparison, alternative definitions of elite and non-elite institutions samples, or variations in the nature of our treatment variable (discrete/continuous).

We acknowledge some limitations in our data, specifically related to the B&B:08/18 dataset used as the main input for projecting students' future income and cumulative student loan amount. As its name suggests, the B&B survey only includes information about students who successfully completed their bachelor's degree, ignoring those who may have dropped out of college. Consequently, our analysis does not consider the potential impact on students who do not complete their college education. This limitation influences our main results in two ways. On one hand, drop-out students may likely have lower future earnings than bachelor's degree completers, making them more likely to benefit from IDR. On the other hand, the shorter duration of their college attendance results in a lower total amount of federal student loans, reducing their likelihood of benefiting from IDR plans. In summary, this limitation's impact is anticipated to offset or be relatively minor in relation to our main findings.

Overall, we find that our results consistently align with the pass-through effects observed in previous studies on the tuition effects of federal aid policies, such as the increase of the Pell Grant amounts (Turner, 2017), the increase of the federal student loan limits (Lucca et al., 2019), and the removal of caps on the Grad PLUS loan (Black et al., 2023). Similar to the response patterns of these federal aid policies, the tuition effects are primarily driven by private, more selective institutions rather than public, less selective ones, likely due to their higher market power. As noted in Turner (2017), "the extent and pattern of capture vary substantially by institutional control and selectivity."

Our findings have direct implications for policy-making. Based on back-of-the-envelope calculations, our results suggest that roughly $23 billion out of the estimated $283 billion cost associated with the recently introduced SAVE plan over the next ten-year budget window will likely be captured by private non-profit institutions and more selective public institutions through increases in net tuition prices.[24] The White House itself has recognized the possibility that the potential benefits for student borrowers derived from the increased generosity of the IDR plans associated with the SAVE plan could be muted by an increase in tuition costs (Council of Economic Advisers, 2024). Our work provides key evidence of this possibility.

[24]We project that President Biden's SAVE plan will incur an approximate cost of $455 billion spanning from 2024 to 2034. Of this total, $172 billion is linked to existing borrowers with disbursed federal loans, while $283 billion is attributed to new loans disbursed annually between 2025 and 2034. See https://budgetmodel.wharton.upenn.edu/estimates/2024/8/20/updated-budgetary-cost-for-president-bidens-save-plan. The impact on tuition fees is specifically applied to the costs associated with new loans and is proportionally distributed among elite sample institutions based on their respective shares among different types of institutions. Based on public-available data from ED and NCES, about 65% of the current federal student loan amount is held by students in four-year public and private non-profit schools. Among four-year public and private non-profit institutions, the elite sample takes up 43% of the total federal student loan amount. About 70% of students from these institutions applied for federal aid. We use the 42.31% semi-elasticity from the discreet analysis since it captures the effect of whether students are estimated to benefit from the policy or not. The total SAVE pass-through effect is therefore calculated as $283 billion $\times 0.65 \times 0.43 \times 0.7 \times 0.4231 =$ $23.43 billion.

References

ALTONJI, J., P. ARCIDIACONO, AND A. MAUREL (2016): "Chapter 7 - The Analysis of Field Choice in College and Graduate School: Determinants and Wage Effects," Elsevier, vol. 5 of *Handbook of the Economics of Education*, 305–396.

ALTONJI, J. G., E. BLOM, AND C. MEGHIR (2012): "Heterogeneity in Human Capital Investments: High School Curriculum, College Major, and Careers," *Annual Review of Economics*, 4, 185–223.

BAUM, S. AND J. DELISLE (2022): "Income-Driven Repayment of Student Loans: Logic, History, and the Need for Reform," Tech. rep., Urban Institute.

BENNETT, W. J. (1987): "Our Greedy Colleges," *The New York Times*.

BLACK, S. E., L. J. TURNER, AND J. T. DENNING (2023): "PLUS or Minus? The Effect of Graduate School Loans on Access, Attainment, and Prices," Working Paper 31291, National Bureau of Economic Research.

CATHERINE, S. AND C. YANNELIS (2023): "The Distributional Effects of Student Loan Forgiveness," *Journal of Financial Economics*, 147, 297–316.

COUNCIL OF ECONOMIC ADVISERS (2024): "The Economics of Administration Action on Student Debt," Available at: https://www.whitehouse.gov/cea/written-materials/2024/04/08/the-economics-of-administration-action-on-student-debt/.

EHRENBERG, R. G. (2012): "American Higher Education in Transition," *Journal of Economic Perspectives*, 26, 193–216.

FILLMORE, I. (2023): "Price Discrimination and Public Policy in the US College Market," *The Review of Economic Studies*, 90, 1228–1264.

GUVENEN, F., A. MCKAY, AND C. B. RYAN (2023): "A Tractable Income Process for Business Cycle Analysis," Working Paper 30959, National Bureau of Economic Research.

HERBST, D. (2023): "The Impact of Income-Driven Repayment on Student Borrower Outcomes," *American Economic Journal: Applied Economics*, 15, 1–25.

KARAMCHEVA, N., J. PERRY, AND C. YANNELIS (2020): "Income-Driven Repayment Plans for Student Loans: Budgetary Costs and Policy Options," *Congressional Budget Office*.

KARGAR, M. AND W. MANN (2023): "The Incidence of Student Loan Subsidies: Evidence from the PLUS Program," *The Review of Financial Studies*, 36, 1621–1666.

KELCHEN, R. (2019): "An Empirical Examination of the Bennett Hypothesis in Law School Prices," *Economics of Education Review*, 73, 101915.

——— (2020): "Does the Bennett Hypothesis Hold in Professional Education? An Empirical Analysis," *Research in Higher Education*, 61, 357–382.

KIRKEBOEN, L. J., E. LEUVEN, AND M. MOGSTAD (2016): "Field of Study, Earnings, and Self-Selection," *The Quarterly Journal of Economics*, 131, 1057–1111.

LOONEY, A. (2022): "Biden's Income-Driven Repayment Plan Would Turn Student Loans Into Untargeted Grants," *The Brookings Institution*, available at: https://www.brookings.edu/articles/bidens-income-driven-repayment-plan-would-turn-student-loans-into-untargeted-grants/.

LUCCA, D. O., T. NADAULD, AND K. SHEN (2019): "Credit Supply and the Rise in College Tuition: Evidence from the Expansion in Federal Student Aid Programs," *The Review of Financial Studies*, 32, 423–466.

NCES (2024a): "Baccalaureate and Beyond Longitudinal Study (B&B)," https://nces.ed.gov/surveys/b&b/about.asp, accessed on March 28, 2024.

——— (2024b): "National Postsecondary Student Aid Study (NPSAS)," https://nces.ed.gov/surveys/npsas/about.asp, accessed on March 28, 2024.

OLDEN, A. AND J. MØEN (2022): "The Triple Difference Estimator," *The Econometrics Journal*, 25, 531–553.

RUGGLES, S., S. FLOOD, M. SOBEK, D. BACKMAN, A. CHEN, G. COOPER, S. RICHARDS, R. RODGERS, AND M. SCHOUWEILER (2024): "IPUMS USA: Version 15.0 [dataset]," https://doi.org/10.18128/D010.V15.0.

SINGELL, L. D. AND J. A. STONE (2007): "For Whom the Pell Tolls: The Response of University Tuition to Federal Grants-in-Aid," *Economics of Education Review*, 26, 285–295.

STANGE, K. (2015): "Differential Pricing in Undergraduate Education: Effects on Degree Production by Field," *Journal of Policy Analysis and Management*, 34, 107–135.

TURNER, L. J. (2017): "The Economic Incidence of Federal Student Grant Aid," Working paper, University of Maryland.

WEBBER, D. A. (2014): "The Lifetime Earnings Premia of Different Majors: Correcting for Selection Based on Cognitive, Noncognitive, and Unobserved Factors," *Labour Economics*, 28, 14–23.

WOLNIAK, G. C., C. E. GEORGE, AND G. R. NELSON (2018): "The Emerging Differential Tuition Era Among U.S. Public Universities," in *Under Pressure: Higher Education Institutions Coping with Multiple Challenges*, ed. by P. N. Teixeira, A. Veiga, M. João Machado Pires da Rosa, and A. Magalhães, Leiden, The Netherlands: Brill, 191 – 214.

Appendices

A Tables and Figures

Table A1. Major Category Mapping with MAJORS23 Variable

Major Category	MAJORS23 from NPSAS and B&B
STEM	Computer and information sciences (01)
	Engineering and engineering technology (02)
	Biological and physical sciences, science tech (03)
	Mathematics (04)
	Health care fields (14)
Arts and Humanities	Humanities (09)
	Architecture (17)
	Design and applied arts (20)
	Library sciences (22)
	Theology and religious vocations (23)
Social sciences	Social sciences (07)
	Psychology (08)
	History (10)
Business	Business (15)
Other	Agriculture and natural resources (05)
	General studies and others (06)
	Personal and consumer services (11)
	Manufacturing, construction, repair, transportation (12)
	Military technology and protective services (13)
	Education (16)
	Communications (18)
	Public administration and human services (19)
	Law and legal studies (21)

Notes: This table shows the mapping from the five major categories described in Webber (2014) to NCES data sets we are using. Column 2 contains the name and specific index number of the majors from MAJORS23 variable from NPSAS and B&B data sets.
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

Table A2. Log Income Change by Gender and Ethnicity

Experience (year)	Male, W	Male, B	Male, A	Male, H	Male, O	Female, W	Female, B	Female, A	Female, H	Female, O
11	0.0406	0.0305	0.0261	0.0286	0.0341	0.0270	0.0238	0.0169	0.0186	0.0169
12	0.0382	0.0286	0.0241	0.0269	0.0320	0.0253	0.0224	0.0155	0.0174	0.0158
13	0.0357	0.0268	0.0221	0.0252	0.0299	0.0237	0.0211	0.0142	0.0162	0.0147
14	0.0333	0.0249	0.0201	0.0234	0.0278	0.0220	0.0198	0.0129	0.0149	0.0135
15	0.0308	0.0231	0.0181	0.0217	0.0257	0.0204	0.0185	0.0115	0.0137	0.0124
16	0.0284	0.0212	0.0161	0.0200	0.0236	0.0187	0.0172	0.0102	0.0125	0.0113
17	0.0260	0.0194	0.0141	0.0183	0.0215	0.0171	0.0159	0.0089	0.0113	0.0102
18	0.0235	0.0175	0.0121	0.0166	0.0194	0.0154	0.0145	0.0075	0.0100	0.0090
19	0.0211	0.0157	0.0101	0.0149	0.0173	0.0138	0.0132	0.0062	0.0088	0.0079
20	0.0186	0.0138	0.0081	0.0132	0.0152	0.0121	0.0119	0.0049	0.0076	0.0068

Notes: This table presents the detailed estimates for Δ_{it} derived from the 2009 ACS data, where Δ_{it} is the expected annual change in log income estimated from the ACS by sex-by-race groups for years 11-20 of experience after college graduation. For column names, W: White, B: Black, A: Asian, H: Hispanic, O: Other.
Source: 2009 American Community Survey (ACS).

Table A3. Summary Triple Difference Estimates for Net Tuition: Predicted FAFSA status

	Net tuition (thousand of dollars)		
	Elite sample (1)	Non-elite sample (2)	Overall sample (3)
Panel A. Pre-Post analysis			
$RS_i^{Benefit} \times FAFSA_i^{pred} \times Post$	2.183*	1.626***	1.765***
	(1.212)	(0.594)	(0.585)
Panel B. Event study analysis			
$RS_i^{Benefit} \times FAFSA_i^{pred} \times \mathbb{1}[t = 2003\text{-}04]$	1.218	0.191	0.438
	(2.080)	(0.477)	(0.868)
$RS_i^{Benefit} \times FAFSA_i^{pred} \times \mathbb{1}[t = 2007\text{-}08]$	0.681	-0.061	0.237
	(2.235)	(0.535)	(0.938)
$RS_i^{Benefit} \times FAFSA_i^{pred} \times \mathbb{1}[t = 2011\text{-}12]$	[Reference]	[Reference]	[Reference]
$RS_i^{Benefit} \times FAFSA_i^{pred} \times \mathbb{1}[t = 2015\text{-}16]$	0.474	1.214	0.960
	(2.377)	(0.810)	(0.987)
$RS_i^{Benefit} \times FAFSA_i^{pred} \times \mathbb{1}[t = 2017\text{-}18]$	5.645*	1.811*	3.081**
	(3.204)	(0.958)	(1.450)
Pre-trends test p-value	0.66	0.97	0.88
N of Observations	67,880	98,660	166,540
N of Institutions	520	340	860

Notes: This table presents summary triple difference estimates of NetTuition_{it} using the same Equation 11 and Equation 12, but replacing $FAFSA_i$ with $FAFSA_i^{pred}$. Columns 1, 2, and 3 report the estimates on the elite sample, non-elite sample, and overall sample, respectively. Panel A reports the estimates using Equation 11, and panel B reports the estimates using Equation 12. NPSAS sample weights are used for all estimates. The pre-trends test p-value come from a joint test of the pre-period placebo effects conducted using only pre-PAYE observations. N of observations and institutions are rounded to the nearest 10 per IES restricted-use guidelines. Standard errors are clustered at the institution level and presented in parentheses (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$).

Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

Table A4. Summary Triple Difference Estimates for Net Tuition: Alternative Elite and Non-Elite Sample Definition

	Net tuition (thousand of dollars)	
	Elite sample (1)	Non-elite sample (2)
Panel A. Pre-Post analysis		
$RS_i^{Benefit} \times FAFSA_i \times Post$	3.931***	-0.283
	(1.336)	(0.385)
Panel B. Event study analysis		
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = 2003\text{-}04]$	1.013	0.392
	(2.256)	(0.442)
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = 2007\text{-}08]$	0.100	0.381
	(2.705)	(0.513)
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = 2011\text{-}12]$	[Reference]	[Reference]
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = 2015\text{-}16]$	3.660	-0.364
	(3.211)	(0.585)
$RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = 2017\text{-}18]$	6.750**	0.139
	(3.140)	(0.629)
Pre-trends test p-value	0.67	0.78
N of Observations	62,810	103,730
N of Institutions	480	370

Notes: This table presents summary triple difference estimates of NetTuition$_{it}$ using Equation 11 and Equation 12 on the alternative definition of elite sample and non-elite sample as defined in subsection 6.2. Columns 1, 2, and 3 report the estimates on the elite sample and non-elite sample, respectively. Panel A reports the estimates using Equation 11, and panel B reports the estimates using Equation 12. NPSAS sample weights are used for all estimates. Pre-trends p-value reports the p-values of estimates of $RS_i^{Benefit} \times FAFSA_i \times \mathbb{1}[t = 2007\text{-}08]$ from Equation 12. N of observations and institutions are rounded to the nearest 10 per IES restricted-use guidelines. Standard errors are clustered at the institution level and presented in parentheses (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$).

Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

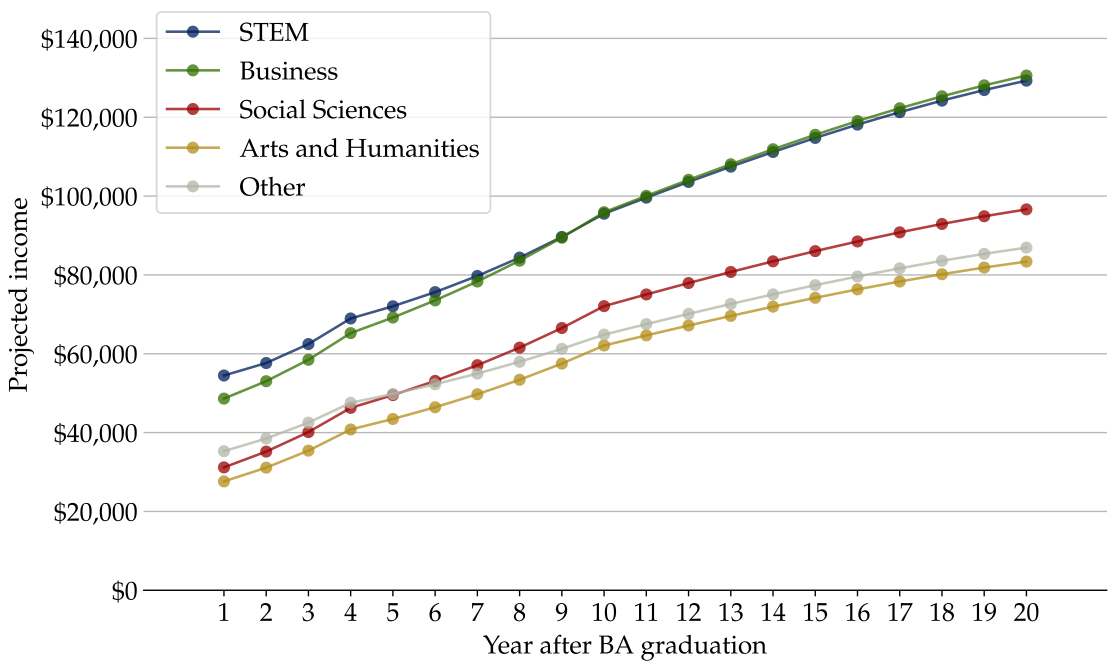
Table A5. Summary Triple Difference Estimates for Net Tuition: Continuous Treatment Variable

	Net tuition		
	Elite sample (1)	Non-elite sample (2)	Overall sample (3)
Panel A. Pre-Post analysis			
$RS_i \times FAFSA_i \times Post$	0.1448***	0.0122	0.0667**
	(0.0507)	(0.0179)	(0.0285)
Panel B. Event study analysis			
$RS_i \times FAFSA_i \times \mathbb{1}[t = \text{2003-04}]$	0.1514	0.0385*	0.0850
	(0.0999)	(0.0228)	(0.0517)
$RS_i \times FAFSA_i \times \mathbb{1}[t = \text{2007-08}]$	0.0375	-0.0046	0.0067
	(0.1038)	(0.0265)	(0.0541)
$RS_i \times FAFSA_i \times \mathbb{1}[t = \text{2011-12}]$	[Reference]	[Reference]	[Reference]
$RS_i \times FAFSA_i \times \mathbb{1}[t = \text{2015-16}]$	0.1828	0.0031	0.0731
	(0.1133)	(0.0351)	(0.0648)
$RS_i \times FAFSA_i \times \mathbb{1}[t = \text{2017-18}]$	0.2177*	0.0315	0.1049*
	(0.1168)	(0.0300)	(0.0618)
Pre-trends p-value	0.66	0.97	0.88
N of Observations	67,880	98,660	166,540
N of Institutions	520	340	860

Notes: This table presents summary triple difference estimates of NetTuition$_{it}$ using Equation 15 and Equation 16. Columns 1, 2, and 3 report the estimates on the elite sample, non-elite sample, and overall sample, respectively. Panel A reports the estimates using Equation 15, and panel B reports the estimates using Equation 16. NPSAS sample weights are used for all estimates. The pre-trends test p-value come from a joint test of the pre-period placebo effects conducted using only pre-PAYE observations. N of observations and institutions are rounded to the nearest 10 per IES restricted-use guidelines. Standard errors are clustered at the institution level and presented in parentheses (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$).

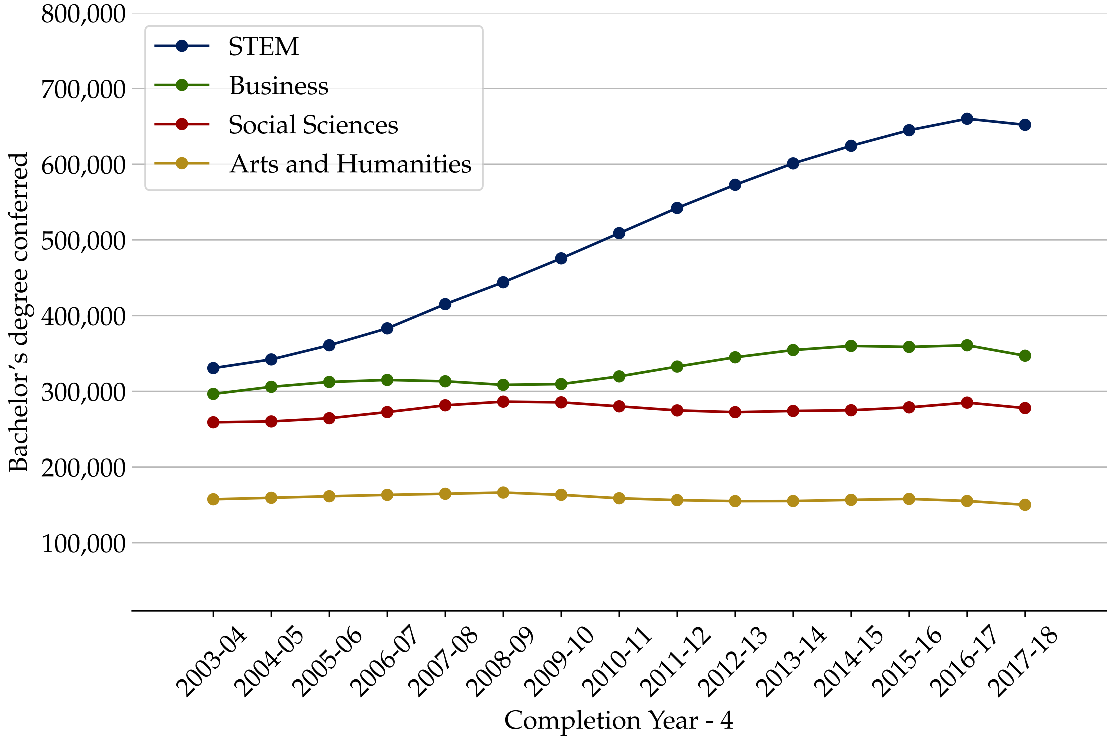
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

Figure A1. Projected Income Trajectory by Major



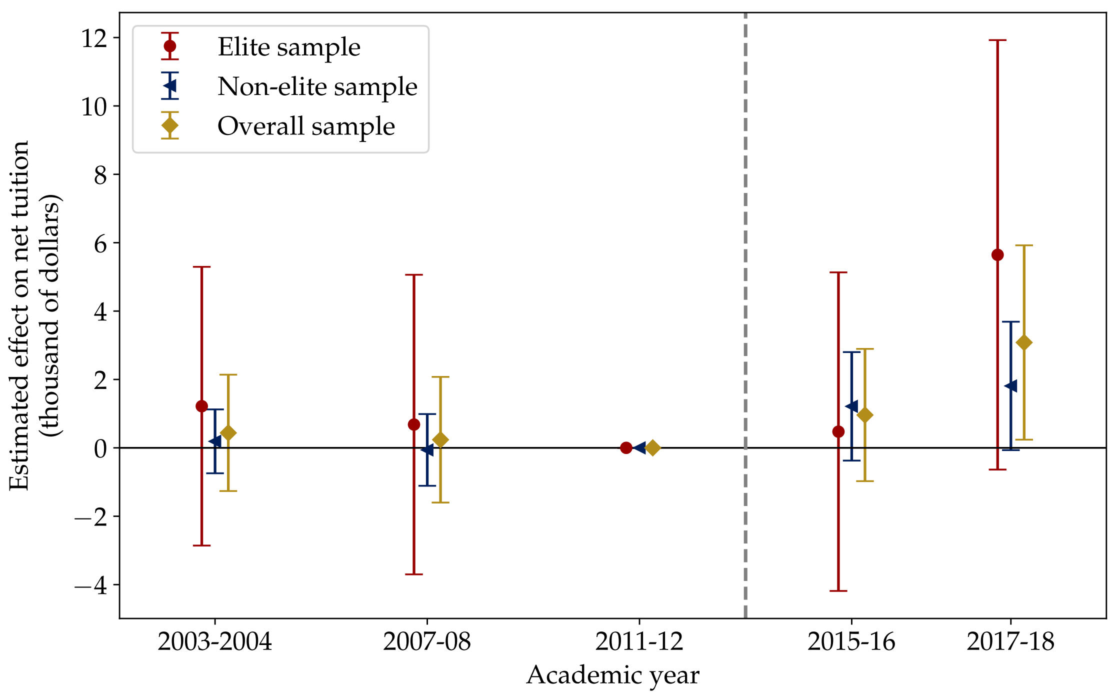
Notes: This figure illustrates the projected average income trajectory, as outlined in subsubsection 3.2.1, spanning from year 1 to year 20 following the completion of a bachelor's degree, by major groups. Numbers are in constant 2021 dollars.
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

Figure A2. Number of Bachelor's Degrees Awarded at Public and Private Non-Profit Postsecondary Institutions



Notes: This figure plots trends in the number of bachelor's degrees awarded at public and private non-profit institutions within specific major groups. The x-axis is the inferred academic year in which the cohorts enter their undergraduate study (completion year - 4). "STEM" includes Computer and Information Sciences and Support Services, Engineering, Engineering Technologies and Engineering-related Fields, Biological and Biomedical Sciences, Mathematics and Statistics, Physical Sciences, Science Technologies/Technicians, and Health Professions and Related Programs. "Arts and Humanities" includes Architecture and Related Services, Liberal Arts and Sciences, General Studies and Humanities, Library Science, Philosophy and Religious Studies, Theology and Religious Vocations, and Visual and Performing Arts. "Social sciences" includes Psychology, Social Sciences, and History. "Business" includes Business, Management, Marketing, and Related Support Services.
Source: U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), Completions component final data (2001-02 - 2020-21) and provisional data (2021-22).

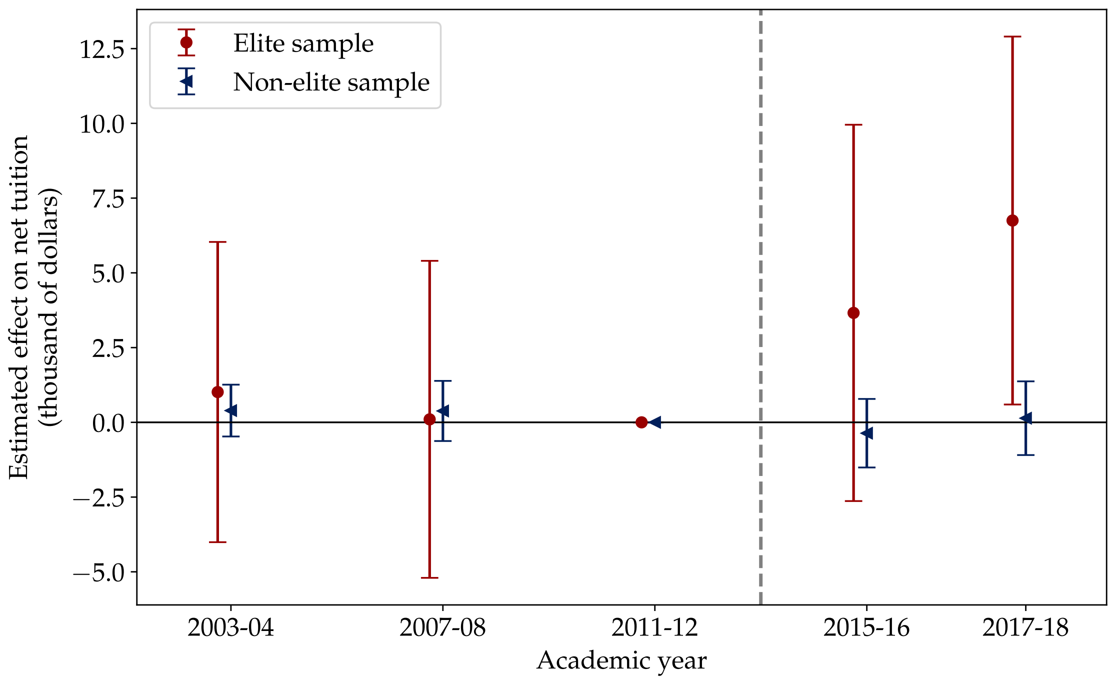
Figure A3. Triple Difference Event-Study Estimates: Predicted FAFSA Status



Notes: This figure plots the estimates of β_τ in Equation 12 for elite sample, non-elite sample, and overall sample institutions, but replacing $FAFSA_i$ with $FAFSA_i^{pred}$ as described in subsection 6.1. The dots, triangles, and squares represent the estimated coefficients and the vertical bars represent the 95 percent confidence intervals. All estimates are weighted by the NPSAS data set sample weights. Standard errors are clustered at the institution level.

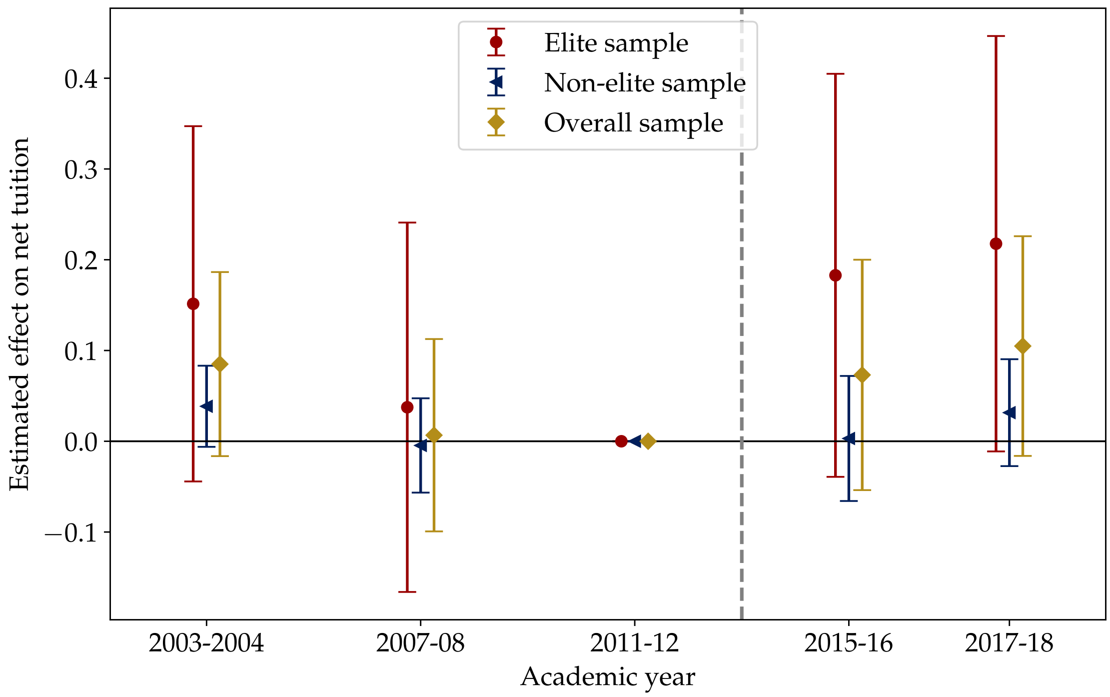
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

Figure A4. Triple Difference Event-Study Estimates: Alternative Definition of Elite and Non-Elite Sample



Notes: This figure plots the estimates of β_τ in Equation 12 for alternative definition of elite sample and non-elite sample institutions, defined in subsection 6.2. The dots and triangles represent the estimated coefficients and the vertical bars represent the 95 percent confidence intervals. All estimates are weighted by the NPSAS data set sample weights. Standard errors are clustered at the institution level.
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).

Figure A5. Triple Difference Event-Study Estimates: Continuous Treatment Variable



Notes: This figure plots the estimates of β_τ on in Equation 16 for elite sample, non-elite sample, and overall sample institutions. The dots, triangles, and squares represent the estimated coefficients and the vertical bars represent the 95 percent confidence intervals. All estimates are weighted by the NPSAS data set sample weights. Standard errors are clustered at the institution level.
Source: U.S. Department of Education, National Center for Education Statistics, 2003-04, 2007-08, 2011-12, 2015-16 National Postsecondary Student Aid Study (NPSAS:04, NPSAS:08, NPSAS:12, NPSAS:16), 2017-18 National Postsecondary Student Aid Study, Administrative Collection (NPSAS:18-AC), and 2008/18 Baccalaureate and Beyond Longitudinal Study (B&B:08/18).