Progressivity of Pricing at US Public Universities

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ABSTRACT: Substantial increases in public university tuition often raise concerns about college affordability. But assessment of the impacts on low- and moderate-income families requires consideration of whether net tuition—tuition less grant aid—has increased commensurately. This paper describes recent shifts in net tuition by family income and institution type and assesses the role of changes in state funding in generating these shifts. Using data reported by universities on net tuition paid by students from different family income levels, we find that public research universities have increasingly shifted to high-tuition, high-aid pricing. From 2012 to 2018, net tuition fell by far more than would have been predicted by the growth in state appropriations, while tuition levels continued to rise, albeit at a slower rate than in the prior years. The increased progressivity in pricing, particularly among research universities, cannot be explained by changes in state appropriations.

Keywords: tuition, public universities, student financial aid

JEL Codes: I23; I2; H7

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Section 0. Introduction

Rising tuition at public universities has brought renewed attention to the questions of "who pays" and "who benefits" from US public higher education. Enrollment-weighted average tuition at four-year public universities increased by nearly 200% between academic years 1987-88 and 2018-19, with increases particularly marked in the years around the Great Recession and then slowing in recent years.[1] Because approximately 70% of students at four-year universities in the US attend a public university, the *potential* burden of increased prices is consequential.

But headline comparisons of tuition charges at public universities do not capture the distribution of prices paid by students from different circumstances. Indeed, the net tuition paid by students from the lowest-income families (less than $30,000 in family income) at four-year universities increased by only 4.5% between 2008-09 and 2018-19, while tuition increased by 32.6%. The affordability and progressivity of higher education depend upon the distribution of grant aid by income and institution type. For the 2018-19 academic year, tuition net of grant aid for students with family incomes under $30,000 was lower at flagship universities (generally regarded as the most selective in the state) than at non-research universities in 36 states, even as tuition is typically higher at flagship universities.[2] As Hansen and Weisbrod (1969) identified 50 years ago, high tuition combined with high aid may be more progressive than low (or zero) tuition.

With data on net tuition paid by family income for in-state students, we measure the "pass-through" rate of tuition changes by family income within each institution. In essence, for each dollar increase in posted tuition, how does net tuition change for students from low- and moderate-income families? Net tuition paid by students with family incomes under $30,000 increases with tuition at a rate of 30 cents per dollar at Carnegie R1 ("very high research activity") institutions, 77 cents per

[1] Unless otherwise noted, statistics in the text and figures are from the authors' calculations based on data from the National Center for Education Statistics' (NCES) Integrated Postsecondary Education Data System (IPEDS).
[2] Appendix Figure 1 illustrates these differences across income ranges for in-state, first-time, full-time students. Throughout this paper we use "tuition" to mean tuition and fees and "net tuition" to mean tuition and fees minus grants and aid that do not have to be repaid. Net tuition may be negative if students receive grants and aid that cover tuition, fees, and some portion of room and board.

dollar at non-research institutions, and 95 cents per dollar at two-year institutions. [3] In effect, research universities appear to engage in more price discrimination by family circumstances than do two-year and non-research four-year institutions.

Descriptive evidence aligning net tuition and tuition changes likely confounds multiple factors affecting tuition, including budget shocks and demand shocks. Changes in state appropriations are an especially policy-relevant budget shock that may impact tuition and, in turn, net tuition paid by students from different circumstances. While it has been well-established that tuition increases less than dollar-for-dollar with declines in appropriations per student (Bound et al., 2019; Deming and Walters, 2017; Chakrabarti, Gorton, and Lovenheim, 2020), this analysis is the first to examine the response of net tuition at different income levels to changes in appropriations. In general, appropriations changes do not explain the increased progressivity of pricing by family income. To organize evidence, we decompose the changes in tuition levels and net tuition into those attributable to state appropriations and other residual factors, including demand-side adjustments in the market. Residual factors beyond changes in state appropriations appear as the most significant force in shaping the progressivity of pricing. We hypothesize that, for research universities, changes in market demand combined with increasingly diversified revenue streams facilitated the shift to high tuition, high-aid pricing, resulting in reductions in net tuition for students with financial need in recent years.

Recent pricing trends are unambiguously more generous for low-income students only if aid increases are coupled with steady or increasing low-income enrollment. A related long-standing concern is that enrollment responses to changes in grant aid are muted relative to changes in tuition if students have incomplete information about the financial aid system (Bettinger et al., 2012; Kane, 1994).[4] We find that changes in low-income enrollment shares in connection with tuition increases

[3] In some cases, we separate out flagship universities, which are often the most resource-intensive in each state. For most of the analysis we employ the Carnegie Classification (2010) taxonomy to distinguish institutions into broad categories based on degrees awarded and research intensity (Carnegie Foundation, 2011). We focus on three aggregates: R1, (those with very high research activity in Carnegie (2010)), R2 and doctoral (high research activity and doctoral universities), and non-research, which includes the remaining four-year degree granting colleges and universities. While there is variation within categories, the R1 universities tend to be the most selective with the highest levels of expenditures per student.

[4] Recent evidence demonstrates that clear communication of full financial aid at a flagship can have a significant impact on enrollment (Dynarski et al., 2021).

are statistically indistinguishable from zero at non-research universities. R1 universities see gains in the representation of low-income students when tuition increases, even as it remains the case that low-income students are relatively underrepresented at these institutions.

Our analysis proceeds with a brief overview of the key institutional details related to tuition setting and grant-based aid at US public universities. The second section turns to the outline of the empirical strategy and data. The third section presents the results, and the final section concludes.

Section 1. Pricing Public Higher Education – Background Evidence

Tuition setting in public higher education represents a combination of political economy factors and market incentives. In the US, higher education is provided through a decentralized and mixed market of private and state-controlled public institutions. State systems of public higher education are stratified—in some cases by design—by selectivity, resources, and pricing, with this stratification increasing over time (Courant, McPherson, and Resch, 2006). In general, public universities have different in-state and out-of-state tuition rates, with the lower "in-state" rate reflecting a subsidy for in-state students. The reduced in-state rate is supported (historically) by state appropriations.

Grant aid produces an additional source of variation in prices paid by students, placing the net tuition paid by students appreciably below the posted tuition level and the average cost of instructional services. Thus, pricing at public universities depends on both posted tuition and the distribution of grant aid. The last two decades have produced marked increases in the level of tuition charged to in-state students, along with the availability of grant aid. What is more, there has been a striking increase in stratification: the most research-intensive universities (which tend to have the greatest level of resources) have seen the largest increases in both tuition levels and grant aid. We set out these pricing characteristics below.

Measuring Grant Aid and Net Tuition Charged

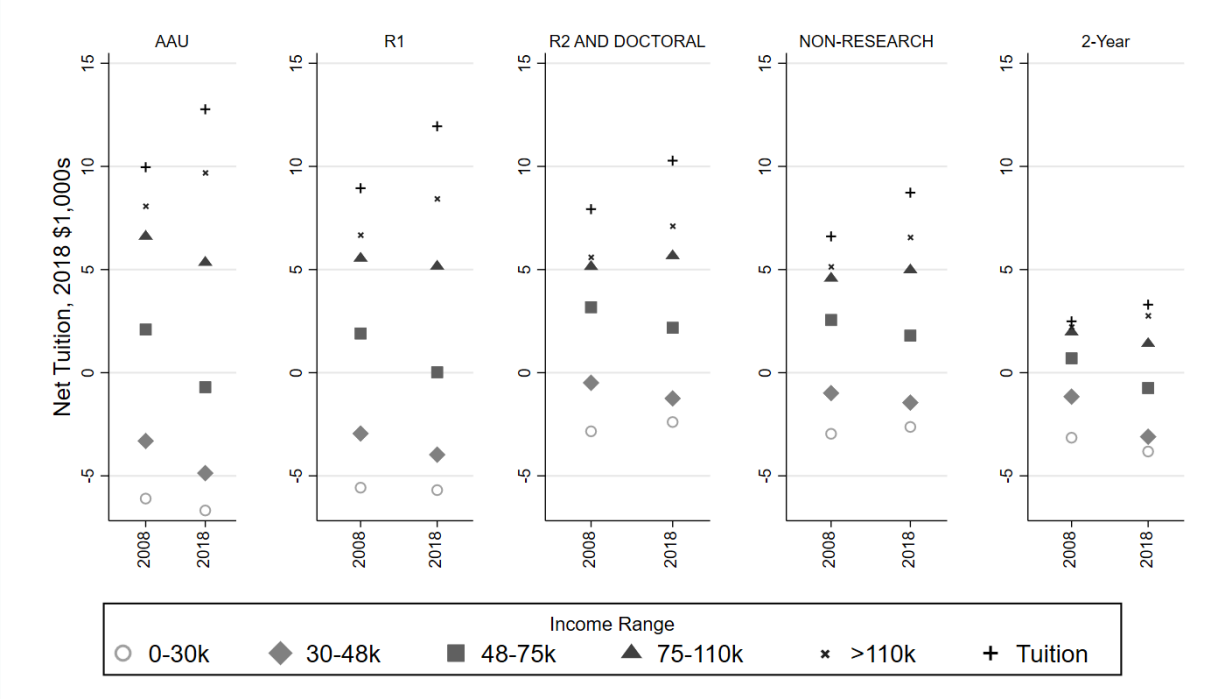
A panel of tuition charges at individual universities has been maintained for several decades by the Department of Education, but trends in net tuition levels by family circumstances are historically hard to find. The challenge is that verified family income is required (given that student self-reports are likely to be error-ridden), along with data on all sources of grant aid (not just a single

source like Pell grants). Our primary data source is a relatively recent addition to the IPEDS surveys, the "Student Financial Aid and Net Price" module.[5] Beginning with the 2008-09 academic year, this module records net tuition and average grants and aid by income group for first-time, full-time, in-state students (at public universities, students from all states at private institutions) who receive Title IV financial aid. Students who complete the FAFSA and receive either federal grants or loans make up the universe of Title IV recipients. While the recording of aid awards by family income is a major step forward in understanding affordability for undergraduate students in IPEDS, the limitation to "first-time, full-time" students limits the generalizability of results. Because first-time, full-time students are a relatively modest share of enrollment as 2-year public institutions, the regression results that follow focus largely on 4-year post-secondary institutions.

Figure 1 summarizes these data for public universities and brings together two critical points of this paper.[6] Between 2007-08 and 2018-19, tuition has risen more at research institutions than at non-research institutions. As shown in the figure, net tuition has fallen for students in all but the highest income bin ($110k +) at public AAU universities (members of the Association of American Universities, generally regarded as some of the most elite, high-resource institutions in the country). Even as tuition and fees increased by about $2,809 (28%) at the AAU universities, net tuition for the lowest income groups fell (-$577 for the $0-$30k income group and -$2,794 for the $48-$75k income group). At non-research public universities and two-year institutions, tuition increases were somewhat smaller, as were the gains in grant aid and concurrent reductions in net tuition. This presentation motivates our analysis of the correspondence among the rising tuition at public colleges

[5] The data present some challenges. For example, the data record family income in nominal categories, which could produce compositional changes in the relative income of families in each bin. This is not a significant problem because inflation was low during our period of observation between 2008-09 and 2018-19. Selection presents another potential problem, as we only observe data for student who applied for aid. However, we do not think this is a significant issue for students from families making $75k or less. Public data from the NCES' National Postsecondary Student Aid Study (NPSAS) support this. In both the 2008 and 2016 NPSAS surveys, first-time, full-year, bachelor's-degree-seeking students at four-year public universities in family income brackets below $75,000 applied for federal aid at rates exceeding 82% for every income group. Application for aid has increased substantially over time for students in higher income groups (on the order of 15 percentage points), so estimates for these groups reflect a greater degree of selection.

[6] While a study of private university pricing is outside the scope of this paper, we include a similar figure for private universities as Appendix Figure 2. Private universities have also seen increase price dispersion since 2008-09.



and universities, the increased stratification in tuition charges between institutions, and the growth in price discrimination by family income within public research universities.

Section 2. Understanding the Tuition-Grant Aid Nexus for Public Universities

Consideration of the university budget constraint and university objectives guides understanding of the determinants of tuition and financial aid at public universities. A public university's revenues include tuition revenues, state appropriations, private gifts, and grants. Tuition revenues are a function of the relative quantities of in-state and out-of-state students, along with the prices charged to each group. On the other side of the budget equation are expenses. In this exposition, we focus on instructional expenditures and institutional grant aid. The former purchases educational resources such as faculty, while the latter effectively purchases specific student characteristics (e.g., non-need-based aid may be used to attract students with higher academic performance, while need-based aid may attract more low-income students). Researchers often model a

university's objective function with student characteristics and instructional resources as inputs (see, for example, Bound et al., 2019 and Epple et al., 2019).[7]

If instructional inputs and student aid are complementary in the university's objective, exogenous negative revenue shocks result in reductions in both instructional inputs and student aid. The extent to which student demand – particularly from families expected to pay full price – is expected to change with increases in tuition (the price elasticity of demand) will impact the price changes chosen by institutions. State appropriations, which are one piece of the revenue side of the budget constraint, likely include some variation that is independent of university actions (Bound et al., 2019). This paper directly examines the effects of appropriations on tuition and net tuition while recognizing that appropriations changes are just one of many factors impacting public universities' pricing decisions. Demand-side factors, including changing demand among students from abroad, likely impact revenue streams and institutional choices (Bound et al., 2020), while universities also respond to other shifting revenue sources and competitive pressures within the US market. Modeling all the margins of adjustment that could contribute to the patterns observed in Figure 1 requires the specification of a demand system and a fuller articulation of the optimization problem, which is beyond the scope of this analysis. Our focus is on understanding the role of changes in state appropriations, as changes in appropriations levels are among the most salient and policy-relevant shocks to public universities' budget constraints since 2008.

The Role of State Appropriations

In 2001-02, appropriations per student hit a peak near $10,000 per student, but in the years immediately following the Great Recession appropriations took a significant hit, dropping to $6,830 per student. The period of our study begins with academic year 2008-09 and ends with 2018-19. During this time, constant-dollar appropriations per student first fell from $8,980 to $6,830 between

[7] Rothschild and White (1993, 1995) motivate the allocation of grant aid in the context of models in which students with different characteristics vary in their importance in a university's objective function or in their contribution to peer learning. Epple et al. (2019) explore price discrimination in higher education in the context of a general equilibrium model in which universities extract rents from high demand students and, in turn, provide subsidies to other students that meet particular institutional needs.

academic years 2008-09 and 2011-12, then recovered slowly through academic year 2018-19 to reach $8,001 (SHEEO, 2020).

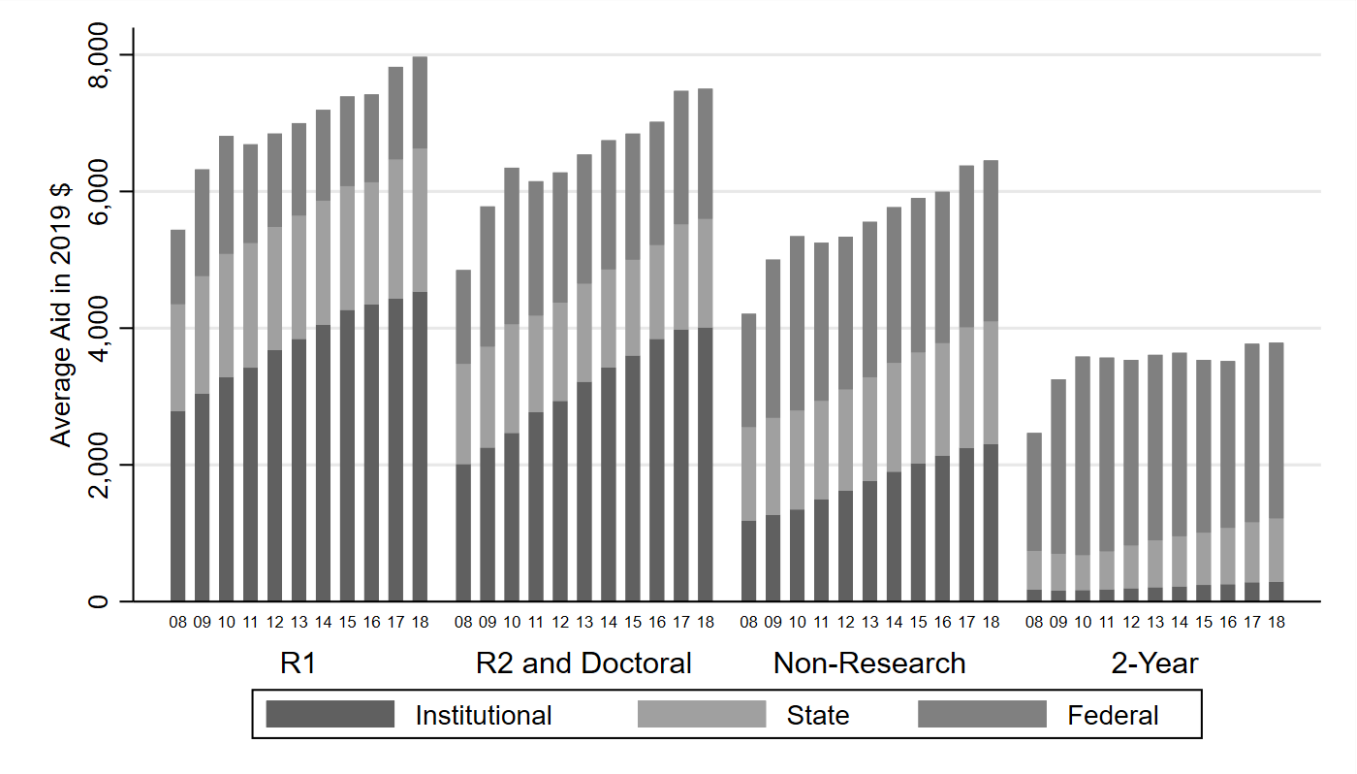
Several recent empirical papers explore how public institutions and student outcomes adjust to appropriations. There is increasing consensus that state appropriations impact educational outcomes, including degree attainment and time to degree through the channel of instructional expenditures (Deming and Walters, 2017; Chakrabarti, Gorton, and Lovenheim, 2020). Other research has shown that appropriations changes induce additional adjustments, such as changes in the composition of students to attract more full-pay students from abroad (Bound et al., 2020). These studies also demonstrate significant price effects, with decreasing state appropriations placing upward pressure on tuition levels. Nonetheless, public universities differ in the extent to which they can change the mix of enrolled students (to include more full-pay out-of-state students, for example). The nature of demand may impact how appropriations declines are accommodated in relation to increases in-state tuition, reductions in expenditures or shifts in the composition of students.

Grant Aid, Tuition and Net Tuition

Grant-based aid comes from federal, state, or institutional sources. The most extensive single program is the federal Pell grant, which provides grant aid to low-income students that is "portable," meaning that students can use these funds to attend any institution. The program had nearly $29 billion in funding in 2018-2019. The constant dollar (2019) maximum federal Pell award per student increased markedly from $5,518 to $6,374 between 2008-09 and 2009-10, with the real value eroding slightly to $6,205 in 2018-19 (Ma et al., 2020). States also offer grant aid to students, totaling about $11.9 billion in 2019 and representing about 13% of total state support for post-secondary institutions (Cummings et al., 2021; Table A2). There has been a substantial aggregate increase in state grant aid programs in the last two decades, with total state grant grant aid to students increasing by 73.4% in constant-dollar terms between 2001 and 2019. Yet, much of the increase occurred between 2001 and 2008, when state grant aid increased from $6.8 to $9.6 billion.

Institutional grant-based aid makes up the largest source of grant aid, totaling $54 billion in awards to all undergraduate students in 2018-19 and representing about 30% of all aid (including loans) awarded to undergraduate students, up from about 18% in 2008-09 (Ma et al., 2020). The

Figure 2: Average Aid Per Student at Public Institutions by Source, 2008-09 to 2018-19



Note: This figure shows average grant aid per student by source, institution type, and year for all full-time, first-year students. The average includes students who receive zero grant aid. The figure includes four groups of public institutions: the universities classified as R1, R2 and doctoral, or non-research in the Carnegie Classification System and two-year institutions. The categories are mutually exclusive. Years are labeled according to the beginning of the academic year (e.g. 08 refers to the academic year 2008-09). For reference, average in-state tuition in 2018-19 for public R1 universities is 11,945, for R2 and Doctoral is $10,280, for non-research is $8,728, and for 2-year institutions is $3,300.

marked change in institutional grant aid that has occurred over the last decade is the rise in awards by public institutions. While private non-profit institutions have a long-standing history of awarding institutional grant aid to meet financial aid and attract students, what has changed markedly in the last decade is level of institutional grant aid at public institutions. The share of first-time, full-time students receiving institutional grant aid at public universities has risen from 38% to 55% between 2008 and 2018.

Figure 2 shows the average per-student grant aid by source and institution type at public universities among all full-time first-year students from 2008-09 to 2018-19. At all four-year public

universities, institutional aid makes up a substantial and increasing share of total aid. Federal grant aid increased between 2008-09 and 2009-10 due to the increase in the maximum Pell grant that year but has been relatively stable since 2009-10. Between 2008 and 2018, per-student state grant aid (constant dollar) increased by $531 at R1, $123 at R2 and doctoral, and $426 at non-research universities. However, most of the increase in grant aid since 2008-09 was from institutional sources. At R1 universities, 69% ($1,746) of the $2,530 increase in per-student grant aid was due to increases in institutional aid. At R2 and doctoral and non-research universities, institutional sources account for 75% and 50% of the increase in grant aid, respectively.

Institutional and state grant aid is awarded based on both need and non-need criteria (including academic and athletic scholarships). The allocation of need-based financial aid follows from a standardized assessment of student and parent capacity to pay (Expected Family Contribution, EFC): the total cost of attendance (tuition plus a room and board allowance) minus EFC is "need." Universities vary in the extent to which they can meet need with institutional grant aid, while there is substantial variation across states in the availability of state grant aid.[8] Institutional grant aid is "last dollar" in the sense that it is applied after state and federal grants. Thus, when tuition levels rise, there is a dollar-for-dollar increase in need for students who already qualify for aid and a concurrent increase in the number of students with need at the extensive margin.

The extent to which universities adjust their own pricing decisions—in both tuition setting and the allocation of institutional grant aid—to state and federal policies has received some consideration in economics research and policy discussions.[9] A first point of consideration is the extent to which public colleges and universities have control over pricing. At a statutory level, the majority of states (43 states and DC) limit the autonomy of public universities to set tuition levels and require some state-level oversight of tuition setting (Pingel and Broom, 2020). At a practical level,

[8] As of Fall 2019, only 11 of 895 national colleges and universities that are ranked by U.S. News and World met full demonstrated need with grant funds, and all 11 were private (Powell and Kerr, 2019).
[9] One explanation, known as the "Bennett hypothesis," is that the increased availability of financial aid, including loans, has shifted demand upward and resulted in higher tuition (Bennett, 1987). Careful work by Archibald and Feldman (2016) argues that there may be some validity to this claim for non-selective private institutions and for-profit institutions, but there is little evidence to support this explanation for tuition increases at most universities.

the result is a dynamic negotiation between institutional and state actors, such that an institution's capacity to raise tuition is a function of the state budgetary circumstances (see Bound et al. (2020) for a model of this principal-agent problem). Where individual colleges and universities have more latitude is in the extent to which they engage in price discrimination, which is generated by the award of financial aid to students on the basis of need or other characteristics.

Yet, empirical evidence on price discrimination in public higher education has been quite limited. The intellectual origins of discussions of differentiated pricing or "high tuition, high aid" policies go back at least 50 years to work by Hansen and Weisbrod (1969).[10] Historically, while private universities tended to have high prices and then distribute subsidies via grant aid, public universities provided across-the-board subsidies to in-state students in the form of low tuition. Even as in-state tuition among public universities is—and has been historically—greater at the most research-intensive within each state than at community colleges or non-research institutions, it is still well below the tuition charged by peer institutions in the private sector. Our work demonstrates that price discrimination by family income is increasing at public universities.

Section 3. Empirical Approach

Our first empirical objective is to quantify the link between tuition and the net tuition charged to students in different income bins. We use a regression framework to describe the extent to which this relationship differs systematically by type of institution and university characteristics.

With observations at the level of the university *(i)* and the year *(t)*, we regress net tuition on tuition following the specification:

$$NT_{itj} = \beta_{0j} + \beta_{1j} Tuition_{it} + \boldsymbol{X_{it}\lambda_j} + \gamma_{tj} + \delta_{ij} + \varepsilon_{itj},$$

where the outcomes of interest, NT_{itj}, are net tuition by income group *(j)*. The regressions include controls for state-level unemployment, the number of high-school graduates, and year and institution fixed effects (γ_t and δ_i). These fixed effects capture secular changes in the entire economy and

[10] Because students from relatively affluent families are represented disproportionately in research universities, particularly the state flagships, some have argued that the distribution of public subsidies is regressive (Hansen and Weisbrod, 1969).

institution-specific time-invariant characteristics. The coefficient of interest, β_1, measures the pass-through rate: the rate at which tuition changes pass through to net tuition. This parameter answers the question: For each dollar increase in posted tuition and fees, what is the expected change in net tuition for students in the indicated income groups?

We run the baseline regressions separately for four institutional classifications: Carnegie R1 universities, R2 and doctoral institutions, non-research four-year institutions, and two-year institutions. While these groups capture meaningful differences across institutions, there are significant differences within these groups in measures that may influence pricing, like baseline resources and characteristics of the university's state. Thus, we also present two specifications in which we include interactions between tuition and: 1) per-student salaries for education and general categories (measured at the start of the observation period), and 2) the state median income. These estimates indicate how the pass-through rate changes with institutional characteristics.

We also examine how the distribution of students by family income within each institution has changed with tuition. Tuition pass-through rates describe how aid per student changes with tuition, but the income distribution of enrollment is also an important indicator of whether institutions are becoming more generous. If low-income enrollment shares decrease while per-student aid increases, this is not unambiguously more generous for low-income students. However, if both enrollment and aid increase, the aid policy is more generous for low-income students. Enrollment shares may change with prices through student application and enrollment decisions, and universities may also regulate enrollment shares by income level in the admission process.

Recent volatility in state appropriations (as discussed in Section 2) raises the question of how state appropriations affect college tuition, other university characteristics, and student outcomes. Our innovation in this context is to examine the link between state appropriations and the net tuition assessed to different income categories. The extent to which appropriations changes impact tuition differently from net tuition depends on how the university prioritizes aid for low-income students relative to other costs. At one extreme, a university would be able to "protect" low-income students if appropriations changes did not affect net tuition; at the other extreme, institutional financial aid could

be a casualty of declines in appropriations, with changes in net tuition coming through both an increase in tuition and a reduction in grant aid from a decline in appropriations.

To provide an empirical assessment, we work with the following specification:

$$NT_{itj} = \beta_{0j} + \beta_{1j} Approp_{it} + \boldsymbol{X_{it}\lambda_j} + \gamma_{tj} + \delta_{ij} + \varepsilon_{itj}$$

With this analysis, we are interested in addressing two questions: first, are appropriations changes felt "across the board," with all income groups facing similar net tuition increases in response to appropriations changes? In turn, to what extent do institutions differ in their capacity to insulate low- and moderate-income students from the adverse impacts of declining state appropriations.

A long-standing concern is that state appropriations received by an institution reflect political considerations that may indicate a desire of legislators to reward (or punish) specific universities in the budgeting process. To the extent that these considerations may also be related to tuition setting, a concern about endogeneity arises. We follow other researchers, including Bound et al. (2019, 2020) and Webber (2017), in arguing that the overall level of state appropriations is an appropriate and necessary instrumental variable for institution-level appropriations.[11] In addition, we control for grant aid to students from state sources, as funding for state grant aid programs may be related to funding for appropriations at the state level. Several recent papers (Deming and Walters (2017) and Chakrabarti, Gorton, and Lovenheim, (2020)) have used variation in appropriations over time at the state level in conjunction with baseline measures of tuition dependence (a shift-share instrument). While both approaches rely on the exogeneity of appropriations changes at the state level, we prefer to focus on variation generated by the overall level of appropriations, because the same factors that generate differences among institutions in baseline tuition dependence may also predict institutional adjustments.

Section 4. Estimation and Results

Net Tuition and Tuition

[11] In state budgets, overall higher education expenditures are often a residual claimant after other priorities (K-12, criminal justice, transportation) are satisfied, with revenue cycles and state tax policy outside the influence of higher education leaders. Bound et al. (2019) provide a comprehensive analysis of the determinants of changes in appropriations at the state level.

Our primary focus is on the extent to which public universities price discriminate in their adjustment in tuition setting and the adjustment of tuition to changes in appropriations. Table 1 shows OLS estimates linking in-state tuition charges to net tuition charged to students in five income groups ($0-30k; $30-$48k; $48-$75k; $75-$110k, and greater than $110k).[12] These net tuition measures are for in-state full-time, first-time freshmen and reflect the net tuition (tuition and fees minus grant-based financial aid from all sources) for students who applied for and received federal financial aid in the form of either grants or loans. Each row shows the share of a dollar increase in posted in-state tuition reflected in net tuition for the ascending income groups, with a coefficient of 1 reflecting full pass-through.[13]

The results in Table 1 show striking differences in price differentiation by family income and type of institution. At community colleges and non-research public universities, a tuition increase leads to a near dollar-for-dollar increase in net tuition for students, including those from the lowest income groups. In contrast, tuition changes at R1 universities do not align with dollar-for-dollar increases in net tuition for low- and moderate-income students. At these universities, an increase in in-state tuition of $1 is associated with an increase of about 30 cents in net tuition for students with family income less than $30,000, moving progressively upward to 43 cents for those in the $48-75k range and then rising to about 73 cents for those with the highest income levels who still receive financial aid. The comparison between R1 universities and non-research counterparts indicates heterogeneity in pricing behavior among public universities.

Interaction Effects

Even within broad university types (R1, R2 and doctoral, and non-research), there remain substantial differences among universities in various measures including expenditures per student, which is often viewed as a measure of quality. Expenditures per student, which may reflect other sources of support like university endowments or research capacity, may impact the extent to which

[12] Appendix Table 1 shows a similar regression but with the institution types "stacked" in the same regression, allowing for easy comparison across institution types.
[13] Recall that for students already eligible for federal need-based financial aid, each dollar increase in tuition produces a dollar increase in "need", though universities are under no obligation to fund this with increased grant aid. For more affluent students, increased price may impact eligibility for need-based aid.

Table 1: OLS Regressions of Net Tuition on In-State Tuition, by Income Group

R1

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+
IS Tuition + Fees	.301**	.394***	.427**	.457***	.733***
	(.126)	(.119)	(.165)	(.142)	(.068)
Observations	791	791	791	791	791
R-squared	.209	.237	.278	.216	.581

R2 AND DOCTORAL

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+
IS Tuition + Fees	.398	.406	.462*	.422*	.675***
	(.262)	(.276)	(.259)	(.233)	(.098)
Observations	1111	1111	1108	1101	1084
R-squared	.175	.135	.114	.113	.279

NON-RESEARCH

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+
IS Tuition + Fees	.77***	.775***	.835***	.89***	.848***
	(.08)	(.078)	(.066)	(.063)	(.056)
Observations	4080	4060	4049	4022	3929
R-squared	.229	.172	.202	.287	.362

2-YEAR INSTITUTION

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+
IS Tuition + Fees	.954***	.951***	.966***	.981***	.985***
	(.05)	(.059)	(.039)	(.049)	(.053)
Observations	9857	9463	9310	8395	6773
R-squared	.22	.207	.199	.139	.197

4-YEAR TOTAL WITH BASELINE E&G INTERACTION

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+
IS Tuition + Fees	.828***	.868***	1.063***	1.092***	.849***
	(.123)	(.12)	(.123)	(.119)	(.074)
Base E&G (1,000s) x TF	-.023***	-.023***	-.032***	-.032***	-.006*
	(.004)	(.004)	(.005)	(.005)	(.003)
Observations	5718	5698	5684	5650	5547
R-squared	.189	.174	.205	.212	.403

Note: This table shows selected coefficients from regressions of net tuition on in-state tuition and fees by income group and institution type. The final panel shows the same regression but with an interaction of tuition and fees with per-student salaries for education and general categories in 2008 (in 1,000s). All regressions include year and university fixed effects, state-level unemployment rate, and high-school graduating cohort size. The regressions are weighted by baseline enrollment. Standard errors are clustered at the university level.

universities can compensate for higher tuition and fees with grant aid. In the final panel of Table 1, estimates of the interaction effect show how differences in expenditures per student (measure in 2007-08) are associated with the pass-through rate. To illustrate, at institutions with baseline per-student salaries for education and general in the 75th percentile, or approximately $12,000 per student (for example, Florida State University, Georgia State University, and the University of Oregon), the estimated pass-through rate for the lowest income bin is about 55 cents per dollar.[14] For students in the $48-75 income bin, the pass-through rate is about 68 cents per dollar. A 25th-percentile institution has per-student education and general salaries around $7,000 (examples include many California State University campuses). For these institutions, the pass-through rates for the $0-$30k and the $48-$75k brackets are approximately 67 and 84 cents per dollar, respectively. Similar estimates by institution type are presented in Appendix Table 2.[15]

Appropriations, Tuition, and Net Tuition

Among the multiple mechanisms potentially driving tuition changes at public universities, the role of adjustments in state appropriations is particularly salient as appropriations on average make up over 20% of total public university non-tuition revenues (National Center for Education Statistics). In Table 2, we show the impact of changes in appropriations on net tuition and tuition, using overall state appropriations as an instrument for appropriations received by the institution. The columns distinguish impacts on net tuition for different income ranges, and tuition in the final column; the rows present the effects by type of institution. The instrumental variables estimates in the final column of Table 2 can be interpreted as follows: for each $1 decrease in appropriations per student at R1 public universities, in-state tuition rates can be expected to rise by 47 cents, while at R2 and doctoral public universities and non-research public universities, the expected tuition increases would

[14] We use education and general salaries because the salaries measure is collected consistently throughout our study period.

[15] In addition, we have considered whether the socio-economic status in the state impacts the degree of differentiation in pricing as states with more potential students from high-income families may be able to raise tuition more while also insulating low-income students from tuition increases. Regressions of net tuition on tuition and interactions with the state's median income (Appendix Table 3) show a statistically significant role for this channel. For each $1,000 increase in the state's median income, the pass-through rate at four-year institutions overall is reduced by between 1 and 2 cents per dollar of tuition for students with family incomes less than $110k.

be 41 cents and 29 cents, respectively. For low-income students, net tuition impacts are relatively small and statistically insignificant, while quantitatively similar across institution types.[16] Where appropriations changes "bite" with the biggest change in net tuition is for students from middle-income families.

Table 2 also highlights the importance of state grant aid to students in determining net price across the income distribution. The second row in each panel of Table 2 shows the association between the average state grant aid per student to all full-time first-year students at the college (including those who receive no aid) and the net tuition within the income bin.[17] State grant aid is positively associated with tuition at all institution types (although the association is statistically insiginificant at R2 and doctoral institutions), suggesting a role for the Bennett hypothesis. A dollar increase in average state grant aid is passed through to net tuition at nearly a dollar-for-dollar rate for lower-income students at all institution types, a pattern that reflects need-based state grant aid programs. However, the effects of state aid are statistically and economically significant across all income groups and at all institution types.

These results complement prior research, which has shown the impact of appropriations on tuition levels and net tuition revenues, by demonstrating the extent to which appropriations affect pricing across the income distribution.[18] Work by Webber (2017) assessing the response of net tuition—defined as tuition revenues from all sources (in-state, out-of-state, and graduate)—to appropriations changes aligns most closely with our results. However, his empirical approach captures all grant aid rather than distinguishing among family income groups. Using data from 1987 to 2014, he finds that each dollar reduction in state appropriations corresponds to an increase of 32 cents in tuition revenue, with effects somewhat larger at doctorate-granting institutions.

[16] Note, as well, these estimated effects are not substantively impacted by the inclusion of 2008-09, in which there was a large increase in the generosity of the Pell grant.
[17] Note that we do not observe state grant aid by income group.
[18] To place these estimates in the context of prior research requires some comparison across specifications. Appendix Table 4 provides estimates of the effect of appropriations on tuition and net tuition measures in specifications where appropriations are in logs, levels, and per-student. The logged version is most comparable to estimates from Bound et al. (2019), who find a coefficient on logged appropriations of -0.157 for public research universities, and -0.338 for the more selective set of AAU universities. Our estimates of -0.258 for R1, -0.279 for R2 and Doctoral, and -0.161 for non-research public universities are in line with these prior estimates; differences are largely explained by differences in the time period studied and our inclusion of state grant aid as an explanatory variable.

Table 2: IV Regressions of Tuition and Net Tuition on Appropriations per Student2

R1

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+	(6) IS T+F
State Appr./Student	-.2	-.202	-.373*	-.866***	-.468***	-.466***
	(.175)	(.188)	(.202)	(.245)	(.154)	(.13)
State Grant/Student	-.811***	-.706***	-.686***	-.767***	-.33**	.361***
	(.128)	(.134)	(.136)	(.176)	(.139)	(.095)
Observations	778	778	778	778	778	778
R-squared	.281	.278	.233	-.179	.288	.617
First-Stage F	29.387	29.387	29.387	29.387	29.387	29.387

R2 AND DOCTORAL

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+	(6) IS T+F
State Appr./Student	-.145	-.286	-.401**	-.371**	-.181	-.406***
	(.179)	(.178)	(.174)	(.157)	(.128)	(.107)
State Grant/Student	-.924***	-.89***	-.722***	-.505***	-.301**	.077
	(.247)	(.231)	(.187)	(.158)	(.141)	(.087)
Observations	1104	1104	1101	1094	1076	1104
R-squared	.221	.156	.051	.019	.153	.532
First-Stage F	54.254	54.254	54.323	54.485	54.443	54.254

NON-RESEARCH

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+	(6) IS T+F
State Appr./Student	-.12	-.246**	-.272***	-.519***	-.083	-.287***
	(.106)	(.101)	(.092)	(.086)	(.076)	(.045)
State Grant/Student	-.862***	-.867***	-.804***	-.692***	-.333***	.111***
	(.088)	(.079)	(.075)	(.091)	(.093)	(.04)
Observations	3790	3769	3758	3731	3638	3790
R-squared	.229	.156	.14	.125	.265	.638
First-Stage F	231.815	233.433	235.969	238.625	255.749	231.815

Note: This table shows selected coefficients from a regression of net tuition on appropriations per student and state grant aid per student by income group and institution type. The final column shows a regression of posted tuition on appropriations per student. All regressions include year and university fixed effects, state-level unemployment rate, and high-school graduating cohort size. The instrument is the state-level appropriations from the State Higher Education Executive Officers Association (SHEEO) per high school graduate in the state. The regressions are weighted by baseline enrollment. Standard errors are clustered at the university level.

Decomposition of Change in Net Tuition: State Appropriations and the Residual

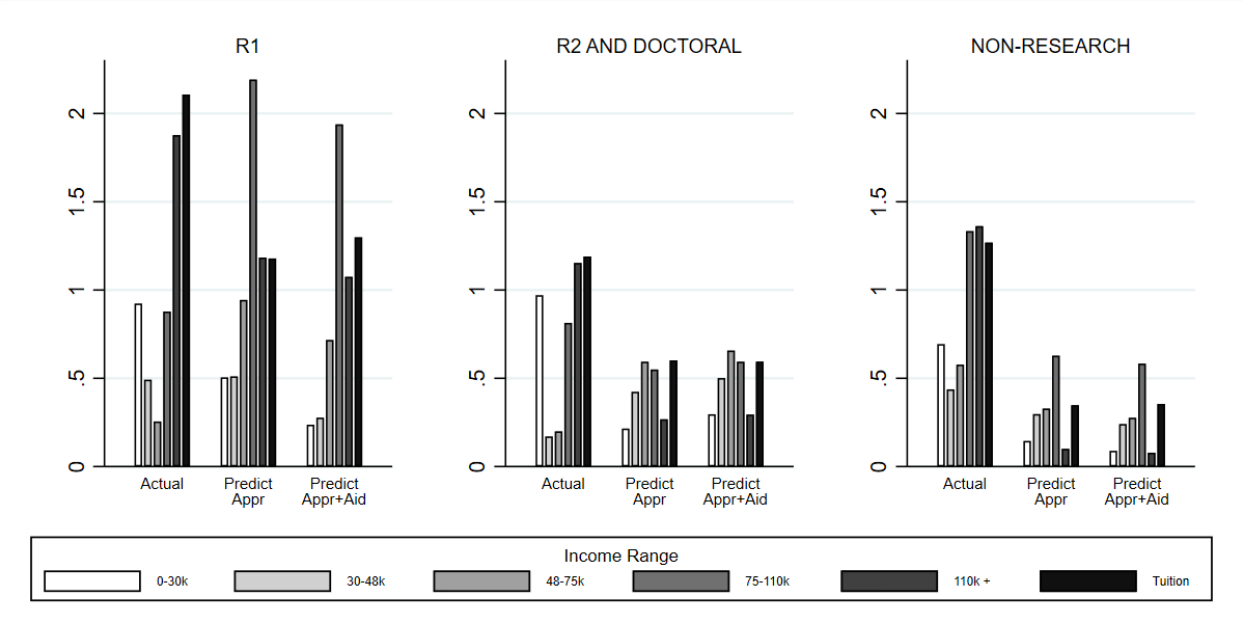
Returning to the overall changes in tuition and net tuition shown in Figure 1, we consider the extent to which the 2008 to 2018 changes in net tuition and tuition can be explained by the shifts in state appropriations versus other factors, including demand shocks and other revenue and cost shocks. We consider two distinct intervals: from 2007-08 to 2011-12, appropriations contracted markedly, while they recovered (to a greater degree for non-research than research universities) in the subsequent years.

Figure 3 illustrates with a decomposition. It shows predicted changes in net tuition and tuition based on changes in state appropriations and grant aid (using the estimates from Table 3), as well as the observed changes in net tuition and tuition. Between 2007-08 to 2011-12, realized tuition changes exceeded those predicted by declines in appropriations and grant aid alone at all types of institutions. Baum et al. (2018) also find that residual growth in tuition levels has been appreciably greater in recent years than can be explained by changes in state appropriations or other sources of government support. Yet, for moderate-income students at R1 universities, realized net tuition increases were less than those predicted from the appropriations changes (which fell by $2,530 per student on average), implying negative residual adjustments lessened the impact of the appropriations change. To illustrate, for students from families in the $48-$75k income bin, the predicted increase in net tuition of $944 (based on appropriations alone) aligned with a realized change of $255. For the non-research universities where appropriations per student declined by about $1,209, the predicted increases in net tuition are less than the observed increases, whether the prediction is based on appropriations alone or on appropriations and state grants.

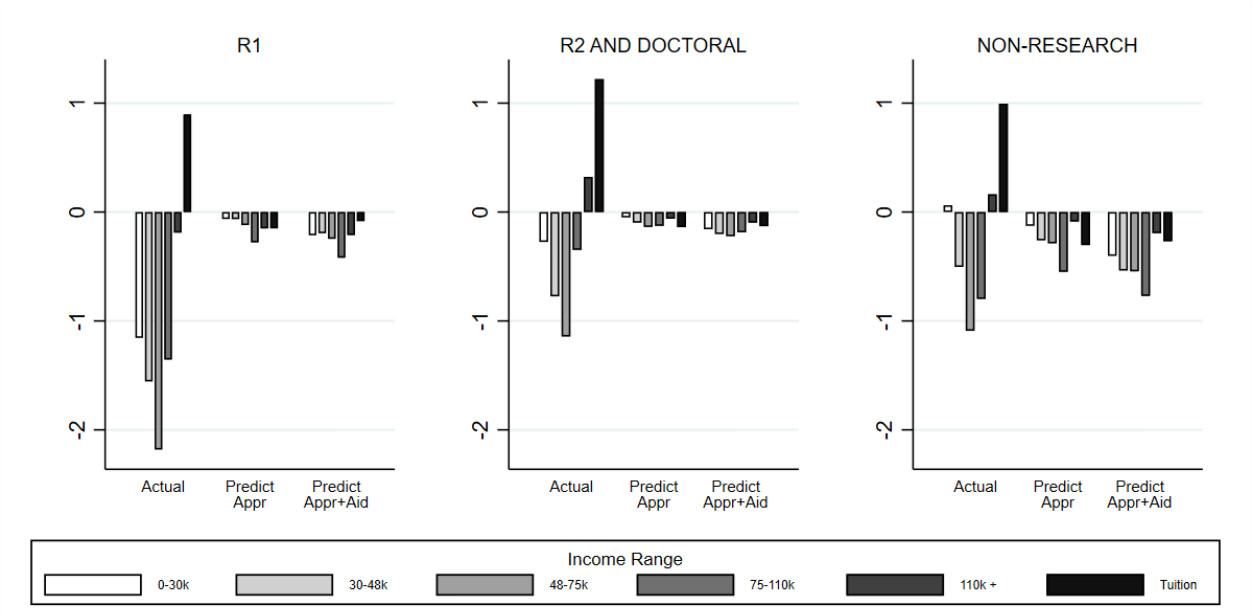
In the second period (from 2012-13 to 2018-19), because appropriations per student increased—recovering 88% of the first-period loss for non-research universities and 13% for R1 universities—the predicted changes point to declines in both net tuition and tuition. Yet, while net tuition did decline, tuition rose across all institutional categories. The actual net tuition rates fell considerably more than predicted in the low- and moderate-income categories for students at R1 universities. In contrast, predicted and actual declines in net tuition are relatively similar for moderate-income categories at non-research universities.

Figure 3. Decomposition of Changes in Tuition and Net Tuition, 2008-2018

Panel A. Change in Actual and Predicted Net Tuition, 2008-09 to 2011-12



Panel B. Change in Actual and Predicted Net Tuition, 2012-13 to 2018-19



Note: This figure shows changes in actual and predicted prices by income group in $1,000s of 2019 dollars. Panel A shows 2008-09 through 2011-12, and panel B shows 2012-13 through 2018-19. Predicted changes due to appropriations are calculated by multiplying the change in appropriations by the IV estimate of the effects of appropriations on net tuition (displayed in Table 2), then taking the enrollment-weighted average of this predicted change across institutions. A second prediction includes the effect of changes in state grant aid along with the effect of appropriations. Appropriations per student declined in the first period by $2,530 for R1, $1,482 for R2 and doctoral, and $1,209 for non-research universities. Appropriations per student increased in the second period by $321 for R1, $346 for R2, and $1,061 for non-research universities.

Table 3: Regression of Enrollment Share by Income Category on In-State Tuition and Fees

R1

	(1) 0-30k	(2) 31k-48k	(3) 48k-75k	(4) 75k-110k	(5) 110k +	(6) NoAid	(7) Total
IS Tuition + Fees, 1,000s	.3**	.323***	.368***	.313***	.194*	-1.499***	-.068**
	(.151)	(.073)	(.073)	(.092)	(.111)	(.289)	(.032)
Observations	791	791	791	791	791	791	802
R-squared	.225	.142	.359	.439	.372	.359	.175

R2 AND DOCTORAL

	(1) 0-30k	(2) 31k-48k	(3) 48k-75k	(4) 75k-110k	(5) 110k_+	(6) NoAid	(7) Total
IS Tuition + Fees, 1,000s	.271	.157	.196	.18	.093	-.897*	.043
	(.246)	(.101)	(.126)	(.165)	(.267)	(.52)	(.033)
Observations	1111	1111	1111	1111	1111	1111	1111
R-squared	.234	.041	.134	.051	.284	.213	.174

NON-RESEARCH

	(1) 0-30k	(2) 31k-48k	(3) 48k-75k	(4) 75k-110k	(5) 110k +	(6) NoAid	(7) Total
IS Tuition + Fees, 1,000s	.064	-.363	-.086	-.252	-.27	.908	.017
	(.636)	(.402)	(.347)	(.33)	(.315)	(1.891)	(.015)
Observations	4080	4080	4080	4080	4080	4080	4080
R-squared	.022	.015	.016	.015	.112	.005	.118

Note: The first six columns show selected coefficients from regressions where the dependent variable is the percentage of in-state students in each income group (measured on a scale from 0 to 100), and the independent variable is in-state tuition and fees, in thousands. The final column shows the effects on the total number of in-state students, where the dependent variable is measured in thousands. The regressions are weighted by baseline enrollment. Standard errors are clustered at the university level.

Tuition and the Distribution of Students

At R1 institutions, the changes in progressivity of pricing by income group are coupled with increases in the proportion of aided students, which reinforces the view that high-resource institutions are becoming more generous with aid even as tuition increases. Table 3 shows how enrollment by income bin varies with tuition levels. In the first five columns, the dependent variable is the percent of first-time, first-year, in-state students who receive FAFSA aid and have family incomes corresponding with the column income range. The dependent variable in the sixth column is the proportion of first-time, first-year students who did not receive aid. By construction, the coefficients sum to zero across the first six column. The dependent variable in the final column is the total number

of first-time, first-year, in-state students. At R1 institutions, increases in tuition are associated with an increase in the share of aided students in all income groups (about 0.3 pp per $1,000 for those with income less than $30,000, 0.323 pp for the $30,000-$48,000 income range, 0.368 for the $48,000 to $75,000 income range, 0.313 in the $75,000 to $110,000 income range, and 0.194 for incomes above $110,000). The total number of students falls by 68 students per $1,000. At other types of institutions, effects on enrollment composition and total enrollment are not statistically different from zero at the 5% level.

Section 5. Conclusion and Further Thoughts

The popular press has devoted much ink to the potentially deleterious effects of tuition increases on opportunities for low-income students (Clark, 2016; Dickler, 2016; Douglas-Gabriel, 2016). We present evidence that runs counter to this narrative; the impact of increasing tuition levels on low-income students is nuanced, varying by institutional characteristics. Even as tuition levels increase, low-income students attending R1 public universities may see increases in aid that more than compensate for tuition increases. To this end, debates among advocates for "free college" and proponents of market-driven tuition policies are likely to miss the most salient issues if they fail to look at the progressivity of tuition pricing rather than just the price charged to students from high-income families.

Our evidence points to increasing average tuition coupled with greater tuition stratification across public universities. The most resource-intensive universities have increased price discrimination by income to such a degree that students from low- and middle-income families now face lower net tuition charges than they did a decade ago. Our analysis suggests that state appropriations changes do not explain the increasing price discrimination at public universities, even as changes in state appropriations do have some impact on baseline tuition levels. Particularly since 2012, other forces have been at work. While a complete understanding of the trend toward the "high-tuition, high-aid" model requires more extensive modeling of public universities' objectives, revenue streams, and interactions with state governments, three factors merit scrutiny in future work. First, the continuing stratification of family incomes over the last decade—with gains for top percentile families outpacing those in the bottom and middle of the distribution—implies that inelastic high-income, in-

state students make up a larger share of the market. Secondly, public institutions, particularly those in the R1 sector, have been increasingly successful in attracting private philanthropic gifts and, while endowment support and gifts earmarked to financial aid remains insufficient to cover institutional grant aid, institutions may have more latitude to fund generous grant aid programs than in prior decades.[19] Finally, public universities are increasingly employing "enrollment management" practices (long used by private counterparts), which enable institutions to better predict how aid offered will increase likelihood of matriculation.[20]

Our empirical evidence demonstrates that tuition increases do not necessarily coincide with increases in net tuition at public universities for low- and middle-income students. While the observed declines in net tuition evident at public universities (particularly research universities) make public universities more affordable, public universities face a persistent challenge in communicating the availability of grant aid to students and their families.

[19] For example, private gifts to public 4-year institutions increased from $5.7 billion in 2007-2008 to $9.3 billion in 2018-19, while giving for endowment and capital accounts also increased (National Center for Education Statistics, 2020).

[20] See Jaquette and Han (2020) for an overview of the increased use of enrollment management practices at public univerisities, particularly as a tool to recruit students able to pay out-of-state tuition level.

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William Winston and Ramiro Burga provided excellent research assistance. We are also exceedingly grateful to Breno Braga and Gaurav Khanna for help with data and code on closely related prior work. We thank Joshua Goodman and Jeff Smith for insightful and constructive comments. This work has benefited from comments from seminar participants at the University of Wisconsin-Madison, Duke University, the Summer Higher Education Seminar Series organized by Dominique Baker and Robert Kelchen, and the Association for Public Policy Analysis and Management Annual Conference. Sarah Turner acknowledges the Bankard Fund for Political Economy at UVa for financial support.

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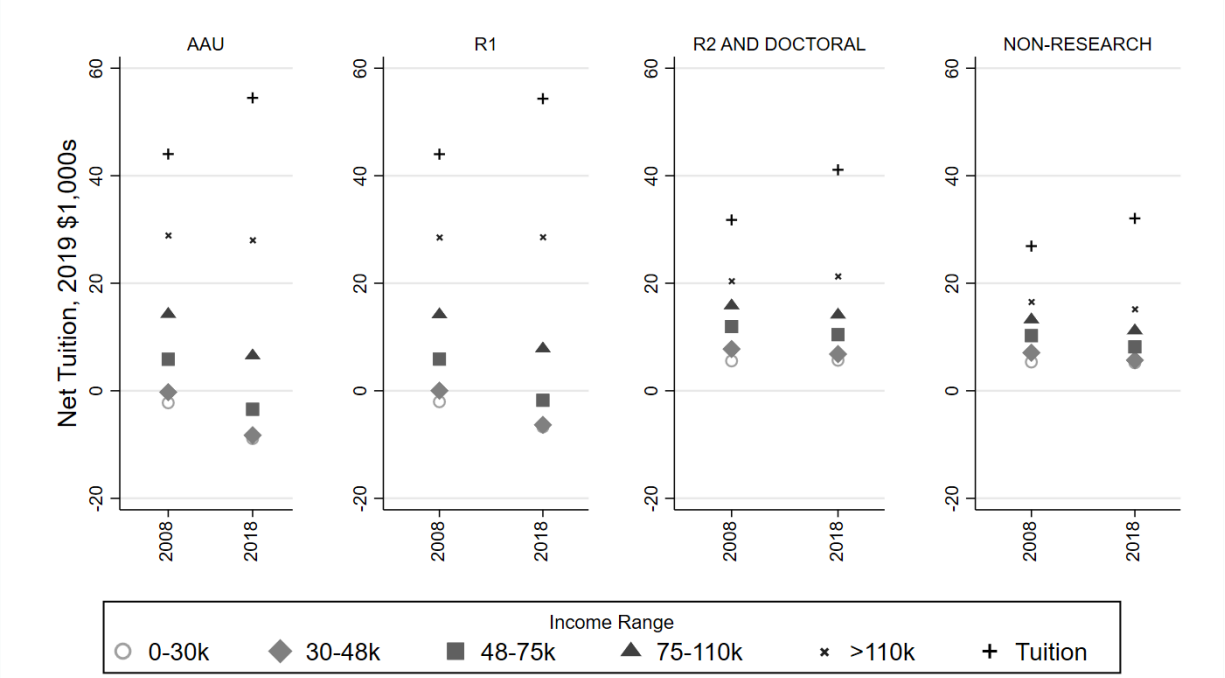
Online Appendix Tables and Figures

Appendix Figure 1: Difference between Flagship and Average Non-Research University Net Tuition by State and Income Group

Note: The figure shows the difference between net tuition at the flagship university and net tuition at the average non-research university by state and income group for the academic year 2018-19. Each panel shows an income group, and each bar is a state.

Appendix Figure 2: Net Tuition by Income and Private Institution Type, 2008-09 and 2018-19



Note: This figure shows net tuition (tuition and fees minus average grants and aid) by income group and private institution type in 2008-09 and 2018-19 for in-state, full-time, first-time students. Net tuition can be negative because grant aid may exceed tuition and fees to cover a portion of room and board. The figure includes four groups of private institutions: members of the Association of American Universities (AAU), the universities classified as R1, R2 and doctoral, or non-research in the Carnegie Classification System. AAU universities are a subset of R1; the other categories are mutually exclusive.

Appendix Table 1: Comparison of Pass-Through Across Institution Types

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+
IS Tuit + Fees R1	-.468***	-.38***	-.408**	-.434***	-.115
	(.147)	(.141)	(.176)	(.153)	(.087)
IS Tuit + Fees R2 and Doctoral	-.371	-.369	-.373	-.468*	-.172
	(.272)	(.284)	(.265)	(.24)	(.112)
IS Tuit + Fees CC	.184*	.176*	.131*	.09	.137*
	(.094)	(.098)	(.077)	(.08)	(.077)
IS Tuit + Fees	.77***	.775***	.835***	.89***	.848***
	(.08)	(.078)	(.066)	(.063)	(.056)
Observations	15839	15425	15258	14309	12577
R-squared	.209	.191	.21	.198	.348

Note: This table shows selected coefficients from a regression of net tuition on in-state tuition and fees by income group. This is identical to Table 1 except that all institution types are in the same regression, allowing comparison of the coefficients relative to the baseline category, which is non-research universities. The regression includes year and university fixed effects, state-level unemployment rate, and high-school graduating cohort. The regressions are weighted by baseline enrollment. Standard errors are clustered at the university level.

Appendix Table 2: OLS Net Tuition on In-State Tuition and Baseline Education and General per Student

R1

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+
IS Tuition + Fees	.865***	.886***	1.049***	1.119***	.817***
	(.226)	(.21)	(.263)	(.265)	(.166)
Base E&G (1,000s) x TF	-.023***	-.02***	-.025***	-.027***	-.003
	(.007)	(.006)	(.009)	(.009)	(.005)
Observations	791	791	791	791	791
R-squared	.239	.263	.312	.262	.582

R2 AND DOCTORAL

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+
IS Tuition + Fees	.469	.701*	.85**	.823***	.825***
	(.411)	(.4)	(.353)	(.282)	(.225)
Base E&G (1,000s) x TF	-.007	-.025	-.032	-.033	-.012
	(.04)	(.04)	(.038)	(.032)	(.017)
Observations	1100	1100	1097	1090	1073
R-squared	.18	.139	.119	.121	.282

NON-RESEARCH

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+
IS Tuition + Fees	.964***	1.016***	1.112***	1.198***	.823***
	(.188)	(.22)	(.223)	(.225)	(.142)
Base E&G (1,000s) x TF	-.025	-.031	-.035	-.038	.002
	(.019)	(.025)	(.027)	(.025)	(.016)
Observations	3827	3807	3796	3769	3683
R-squared	.231	.175	.203	.295	.366

2-YEAR INSTITUTION

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+
IS Tuition + Fees	1.011***	1.053***	1.067***	1.104***	.935***
	(.086)	(.096)	(.083)	(.127)	(.138)
Base E&G (1,000s) x TF	-.01	-.017	-.018	-.024	.008
	(.012)	(.013)	(.012)	(.019)	(.02)
Observations	9621	9241	9101	8246	6673
R-squared	.219	.204	.199	.14	.198

4-YEAR INSTITUTION, TOTAL

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+
IS Tuition + Fees	.828***	.868***	1.063***	1.092***	.849***
	(.123)	(.12)	(.123)	(.119)	(.074)
Base E&G (1,000s) x TF	-.023***	-.023***	-.032***	-.032***	-.006*
	(.004)	(.004)	(.005)	(.005)	(.003)
Observations	5718	5698	5684	5650	5547
R-squared	.189	.174	.205	.212	.403

Note: The table shows selected coefficients from a regression of net tuition on in-state tuition and fees and an interaction with per-student salaries for education and general in 2008 (in 1,000s). All regressions include year and university fixed effects, state-level unemployment rate, and high-school graduating cohort. The regressions are weighted by baseline enrollment. Standard errors are clustered at the university level.

Appendix Table 3: OLS Net Tuition on In-State Tuition and State Median Income

R1

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+
IS Tuition + Fees	.442	.944***	1.823***	2.003***	.882***
	(.357)	(.282)	(.426)	(.447)	(.268)
Median Inc x IS TF	-.002	-.009**	-.022***	-.025***	-.003
	(.005)	(.004)	(.006)	(.007)	(.004)
Observations	791	791	791	791	791
R-squared	.211	.246	.329	.298	.586

R2 AND DOCTORAL

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+
IS Tuition + Fees	1.159***	1.408***	1.598***	1.141***	.649***
	(.387)	(.353)	(.304)	(.284)	(.243)
Median Inc x IS TF	-.012	-.015**	-.018***	-.011*	0
	(.008)	(.007)	(.006)	(.006)	(.003)
Observations	1111	1111	1108	1101	1084
R-squared	.187	.157	.148	.13	.279

NON-RESEARCH

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+
IS Tuition + Fees	1.097***	1.449***	1.731***	1.404***	.915***
	(.192)	(.22)	(.215)	(.197)	(.183)
Median Inc x IS TF	-.005*	-.011***	-.014***	-.008***	-.001
	(.003)	(.003)	(.003)	(.003)	(.002)
Observations	4080	4060	4049	4022	3929
R-squared	.231	.182	.223	.297	.363

2-YEAR INSTITUTION

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+
IS Tuition + Fees	.95***	1.396***	1.619***	1.352***	.92***
	(.151)	(.208)	(.139)	(.18)	(.194)
Median Inc x IS TF	0	-.007**	-.01***	-.006**	.001
	(.002)	(.003)	(.002)	(.003)	(.003)
Observations	9857	9463	9310	8395	6773
R-squared	.221	.208	.205	.144	.198

4-YEAR INSTITUTION, TOTAL

	(1) NT:0-30k	(2) NT:30k-48k	(3) NT:48k-75k	(4) NT:75k-110k	(5) NT:110k+
IS Tuition + Fees	.958***	1.278***	1.7***	1.499***	.855***
	(.199)	(.163)	(.172)	(.181)	(.12)
Median Inc x IS TF	-.009***	-.013***	-.02***	-.016***	-.002
	(.003)	(.003)	(.003)	(.003)	(.002)
Observations	5982	5962	5948	5914	5804
R-squared	.171	.166	.2	.192	.399

Note: The table shows selected coefficients from a regression of net tuition on in-state tuition and fees and an interaction of tuition and fees with median household income (in $1,000s). All regressions include year and university fixed effects, state-level unemployment rate, and high-school graduating cohort. The regressions are weighted by baseline enrollment. Standard errors are clustered at the university level.

Appendix Table 4: Effects of Changes in State Appropriations on In-State Tuition and Fees, 2008-2018

R1

	(1) IS T+F	(2) IS T+F	(3) IS T+F	(4) IS T+F	(5) ln(IS T+F)	(6) ln(IS T+F)
State Appr. (1,000s)	-.004***	-.015***				
	(.001)	(.005)				
State Appr./Student			-.135***	-.466***		
			(.042)	(.13)		
ln(State Appr.)					-.098**	-.258***
					(.039)	(.09)
Observations	778	778	778	778	768	768
R-squared	.704	.563	.705	.617	.698	.664
First-Stage F		13.993		29.387		119.147
Model	OLS	IV	OLS	IV	OLS	IV

R2 AND DOCTORAL

	(1) IS T+F	(2) IS T+F	(3) IS T+F	(4) IS T+F	(5) ln(IS T+F)	(6) ln(IS T+F)
State Appr. (1,000s)	-.004*	-.012***				
	(.002)	(.005)				
State Appr./Student			-.071**	-.406***		
			(.034)	(.107)		
ln(State Appr.)					-.04	-.279***
					(.032)	(.081)
Observations	1106	1106	1104	1104	1103	1103
R-squared	.664	.631	.665	.532	.676	.552
First-Stage F		27.492		54.254		112.611
Model	OLS	IV	OLS	IV	OLS	IV

NON-RESEARCH

	(1) IS T+F	(2) IS T+F	(3) IS T+F	(4) IS T+F	(5) ln(IS T+F)	(6) ln(IS T+F)
State Appr. (1,000s)	-.004***	-.009***				
	(.001)	(.002)				
State Appr./Student			-.04**	-.287***		
			(.017)	(.045)		
ln(State Appr.)					-.034	-.161***
					(.023)	(.031)
Observations	3800	3800	3790	3790	3777	3777
R-squared	.715	.709	.713	.638	.713	.686
First-Stage F		193.548		231.815		420.072
Model	OLS	IV	OLS	IV	OLS	IV

Notes: All regressions include state grant aid to full-time, first-year students (measured in total, per student, and logs to correspond with the measure of appropriations), year and university fixed effects, state-level unemployment rate, and high-school graduating cohort size. The regressions are weighted by baseline enrollment. Standard errors are clustered at the university level. The instrument in the IV regressions is constructed from the state-level appropriations from the State Higher Education Executive Officers Association (SHEEO). The instrument is in levels, appropriations per high school graduate in the state, and logs, corresponding to the units of institutional appropriations in the second stage.