Stagnating Public University Finances and Faculty Composition

Senan Hogan-Hennessy[*†]

9 August 2022

Abstract

State support for public universities has stagnated the last thirty years, while enrollment has secularly increased. At the same time, public universities have reduced the number of professors per student on tenure-track or with tenure, while increasing their employment of contingent lecturers. This analysis relates changes in the faculty composition at public universities to the changes in per student university revenues from state appropriations, addressing endogeneity in state appropriation decisions by a shift-share instrumental variables approach. An increase of university revenues of 10%, via a change in state appropriations, increases the number of assistant professors per student by 6.6% and full professors by 5.3%, yet decreases the number of lecturers per student by 14.3%. Analysis of all the professors hired at Illinois public universities 2011-2021 implies that incumbent professors are not affected by the changes in university revenues, so that changes in faculty composition arises by changes in hiring practices at public universities. These results show the compositional effects of stagnating state support for higher education, and raise questions about the direction that public education heads as these financial headwinds continue.

Keywords: State and Local Budget and Expenditures, Higher Education, Public Sector Labor Markets

JEL Codes: H72, I23, J45

[*] Cornell University, Department of Economics.

[†] I thank Professor Evan Riehl for guidance on this project, Michael Lovenheim, Ronald Ehrenberg, Douglas Miller, and Francine Blau for various comments on the project's direction, as well as seminar participants at Cornell University (Autumn 202) for helpful discussion. This project's Github repository, with materials and (publicly available) data for replication, is available at https://github.com/shoganhennessy/finances-faculty-composition. Any comments or suggestions may be sent to me at seh325@cornell.edu, or raised as an issue on the Github project.

Public universities educate the majority of higher education students in the US, yet have experienced a secular decline in state funding (per student) the last three decades. This decline has been shown to lead to worse education and later-life outcomes for students (Deming & Walters 2017, Chakrabarti, Gorton & Lovenheim 2020), yet it is not clear what mechanisms drive these effects or how public universities are affected as institutions. I show that four-year, degree-granting public universities have experienced falling state funding, leading to falling revenues per student, effecting the composition of professors within public universities in general. Falls in public university revenues from the state, instrumented by state-level finance shocks, lead to a fall in the number of tenure-track or tenured professors per student within a university, an increase in the number of lecturers, and overall fall in the number of faculty per student. US private universities were not exposed to such financial constraints during this same time period, and do not exhibit the substitution away from tenure-track and tenured professors, so that the stagnating state support for public universities has implications for the structure of higher education instruction and research in the US.

US Universities are widely considered the highest performing in the world, yet there are consequential differences between its universities that operate in the private sector and those established by state governments. public universities are subject to numerous state-level administrative laws, and rely on their state governments for funding: an average PU received around \$11,600 per enrolled student in 1990, yet only \$8,300 per enrolled student in 2021.[1] This fall is driven by stagnating funding provided by state governments, while total enrollment among public universities rose by 46% over the same time period. At the same time, the number of professors per student at public universities stayed relatively stable at 0.045, yet fell from around 0.04 to around 0.35 professors per student at public universities, driven by a fall of over 20% in the ratio of associate and full (i.e. tenured) professors per student at

[1] 2021 figures are relatively similar to those for year preceding, despite the Covid-19 pnademic and associated financial shocks, since 2021 refers to the academic year 2019-2021 and so the yearly budget was decided in 2019. This paper does not directly analyse budget shocks related to the Covid-19 pandemic, or any other events in 2021 and following.

public universities.[2]

I use a variant of the Deming & Walters (2017), Chakrabarti et al. (2020) shift-share instrument for PU revenues from shocks to state appropriations to identify the effect on the faculty composition. State appropriations for public universities are plausibly endogenous to many outcomes: state governments decide on yearly budgets for their higher education sector, and this process can be influenced by local financial conditions, or even public (and political representatives') perceptions of the state's higher education system. The shift-share instrument interacts reliance on state funding in a base period with the yearly total appropriations per student in the entire state, to exploit both changes in state support for higher education and how much each university relies on that support.

Findings show that negative changes in university revenues affects faculty composition at public universities, away from tenured and tenure-track professors towards non-tenure track lecturer positions. A reduction of 10% in university revenues, via a shock to state appropriations, leads to a fall in 6.6% in the number of assistant professors per student within a university, 5.3% for full (tenured) professors, and a reduction in 14.3% for lecturers. Additionally, I use individual level data on professors who were hired at Illinois public universities 2011-2021 to investigate whether the shocks to university revenues affected incumbent professors at public universities. Incumbent professors were not meaningfully affected, in terms of total salary, promotion rate, or rate of leaving the Illinois public university system, which implies that changes in faculty composition came about by changes in the composition of hiring new professors at the university level.

Deming & Walters (2017) first study the effect of (changes in) public universities' finances on student outcomes by isolating changes in public universities' expenditures on student instruction, addressing endogeneity of expenditures decisions by instrumenting expenditures by an instrument for state appropriations and tuition caps. Deming & Walters (2017) find

[2] Figure 3 and subsection 1.2 document these trends between private and public universities in full detail.

that increases in PU spending (via state appropriations) increases enrolment and degree completion among students, but corresponding changes in attendance price (via tuition caps/freezes) do not have an effect. Chakrabarti, Gorton & Lovenheim (2018), Chakrabarti et al. (2020) use the same instrument for PU revenues at the state level, combined with richer information on students' individual-level outcomes, to show that increases in state appropriations lead to lower time to completion and debt levels among students later in life. Bound, Braga, Khanna & Turner (2019) use another variant of the same approach to show that state-level higher education spending cuts induced public universities to shift toward tuition as their primary source of revenue, and shift institutional resources towards students who pay higher tuition rates. In a similar vein, Bound & Turner (2007) document variation in per student state funding for higher education resulting from yearly changes in a state's student-age population; they find that lower per student funding lead to lower higher education completion rate among students.

University professors the core component of this country's educational and research/innovation university system, yet their composition within universities and its relationship with higher education finances has so far not been studied. Brown, Dimmock, Kang & Weisbenner (2014) presents the closest example by studying how university endowments react to negative financial shocks, exhibiting an association between negative endowment shocks and a fall in tenure-system faculty employed at the university. Abe, Watanabe et al. (2015) present a model for university administrator decision-making, and posit that a large component of variation in faculty salaries arises from university politics, and not only economic factors such as outside. Johnson & Turner (2009), Courant & Turner (2019) both empirically document allocation of faculty between research and instruction, and Hemelt, Stange, Furquim, Simon & Sawyer (2021) document differences in instructional cost (per student) between departments, primarily thanks to department differences in class size and faculty salaries. Turner (2014) document how universities reacted to the Great Recession of 2008, a severe financial shock to state finances, including implementing hiring freezes. Indeed, Cornell University[3] implemented both hiring freezes and even a nominal salary reduction for professors, in anticipation of oncoming financial shock in early 2021.[4]

The number of professors, in absolute terms as well as relative to number of students in the university, may be particularly important for quality of instruction and thus educational outcomes. Angrist & Lavy (1999) first causally show that reducing class size induces an increase in test scores for school-age children, yet the magnitude of the effect is not as clear in the university setting. Bandiera, Larcinese & Rasul (2010) use a fixed effect model, combined with multiple individual observations in a long panel, to find that UK university students perform worse academically in particularly large classes, and the effect is particularly largest for students at the top of the academic distribution. And for the composition of faculty teaching university classes, Bettinger & Long (2010), Figlio, Schapiro & Soter (2015) find US students have better enrollment and learning outcomes from courses taught by contingent or adjunct (i.e. not tenured or on tenure-track) professors (relative to tenured or tenure-track). While Ehrenberg & Zhang (2005) observe a negative association between utilisation of non-tenured instructors and student graduation rates. My approach focuses on count of professors per student at universities, so does not directly observe individual class-sizes, yet presents this as a possible mechanism through which the negative effects on student outcomes that falls in PU finance Deming & Walters (2017), Chakrabarti et al. (2020) document.

This analysis finds that faculty composition is meaningfully affected by recent stagnation in state support for higher education. Analysis of outcomes for incumbant professors in Illinois implies that the explaining mechanism is changes to hiring by public universities in response to the increased financial constraints. Previous findings from the literature on the effectiveness of tenured and tenure-track faculty versus contingent faculty in the areas of research and teaching. Combined with this analysis, these findings provide a plausible

[3]Cornell University is, indeed, only partially public, so that this information is not free information, and cannot be presented with aggregate or verified sources of public data on such salaries.

[4]The salary cut was not permanent, as the oncoming financial shock turned out to not be as serious as projected, and the salary cut was returned to professors in the year 2021.

mechanism for the deteriorating student ouctomes shown to be a result of stagnating finances at public universities (Deming & Walters 2017, Chakrabarti et al. 2020).

1 Data and Institutional Context

1.1 Data Description

The data used in this analysis come from two primary sources: *US Department of Education Integrated Postsecondary Education Data System* (2021, IPEDS) regarding institutional information on finances and enrollment, and *Illinois Board of Higher Education* (2021, IBHED) for a panel of individual-level of every Professor employed by the Illinois PU system.

IPEDS is a survey of higher educational institutions in the US, and legally requires institutions to participate in order to receive Federal Title IV student aid.[5] Data are consistent between the years 1990 and 2021,[6] and provide information on the total revenues a university received from every source (including state governments), enrollment number, plus faculty count and total expenditures on salaries.[7] I restrict analysis to four-year institutions, as these institutions adhere to a standardised concept of faculty profile – that is, tenure and title of appointment (lecturer, assistant professor, etc.) are relatively standardised in four-year, degree-granting institutions. Additionally, for-profit institutions employ and enrol a negligible share of professors and students respectively, while students at two-year institutions by majority intend to eventually enroll at a four-year institution (Mountjoy 2022).[8]

[5]This statement means that IPEDS does not necessarily cover the universe of US higher education institutions, yet thin practice every PU and not for-profit four-year institution is represented.

[6]The years 1987-1989 are represented in these data in an incompletion fashion, so I focus on the years 1990 onwards. Year refers to the calendar year of the spring term — i.e. 1987 refers to the academic year that ran August 1986 to July 1987.

[7]I combine the Urban Institute's 2018 compilation of IPEDS data for the years 1990-2017, and manually combine with raw NCES data regarding the year 2018-2021 for all relevant variables. Figures for enrollment, faculty counts and salaries come from the raw NCES version of IPEDS for all years to address inconsistencies in the Urban Institute's data formulation for these variables.

[8]Furthermore, Mountjoy (2022) documents the effects of expanding two-year higher education access in the US separately for students who would have and those who would not have otherwise have attended

Importantly, IPEDS reports the count of professors employed by category, as well as total salary expenditures by category. This gives a resulting panel data-set, where each row represents a university-year, and includes columns for university finances, plus total count and average salary[9] for professors by category (lecturer, assistant, tenured, total). Table 1 presents summary statistics for relevant variables in the panel of PU-years.

Table 1: IPEDS Summary Statistics, Public Universities Panel 1987–2021

Statistic	Mean	St. Dev.	Median	N
Enrollment, full-time equivalent	11,511	10,821	7,723	18,504
State appropriations (millions 2021 USD)	99	125	52	18,504
Total revenues (millions 2021 USD)	425	793	158	18,504
Lecturers count	60	74	34	17,329
Assistant professors count	113	102	84	17,826
Full professors count	261	284	162	17,929
All professors count	429	437	284	18,504
Lecturers mean salary (2021 USD)	58,212	13,244	56,215	16,686
Assistant mean salary (2021 USD)	74,319	13,849	72,191	17,750
Full mean salary (2021 USD)	99,675	23,590	95,229	17,837
All mean salary (2021 USD)	81,570	25,055	80,582	17,759

IPEDS provides information at the university level, yet lacks information on the distribution of salaries and professor count within a university.[10] To investigate the distribution, I integegrate individual-level data for every PU professor in the state of Illinois between the years 2010-2021. IBHED host the information; Public Act 96-0266 (effective 1 January 2010) requires that each university report base salary and benefits all administrators, faculty members, and instructors employed by the college or university.[11] This publicly available data

college. The high rate of eventual enrollment at four-year institutions among two-year students explains the negative impact of increased access to two-year institutions on students who are diverted away from four-year institutions.

[9]Real salary is computed by scaling nominal salary to 2021 dollars by the CPI-U.

[10]IPEDS provides total paid to salary and total faculty employed per university-year, so that I can investigate average professor salary per university-year with IPEDS data. Unfortunately, it seems that this measure of professors' salaries is particularly crude in measuring on professors' salaries and other individual-outcomes; summary statistics on IPEDS data do not agree with trends in average professor salary over the sample time period (American Association of University Professors 2021).

[11]The universities included are all campuses of the eight Illinois public universities: Chicago State Univer-

provides the basis to build a panel of Illinois PU professors 2010-2021; I define a professor as an individual observation by their first plus last name and university pairing, and link this database to IPEDS information on finances for their employing institution.

The analysis sample represents 16,932 professors in the year 2010 and 15,352 in the year 2021, with summary statistics presented in Table 2. Additionally, further analysis using the first year of a professor's employment focuses on the subset of professors with observed year of hiring between the years 2011 and 2021, representing 1,778 professors in 2011, and 9,099 in 2021.[12] Summary statistics for this group, which over-represents lecturers compared to assistant and full professors, can be seen in Table A1.

Table 2: IBHED Summary Statistics, Professor Panel 2010–2021.

Statistic	Mean	St. Dev.	Median	N
Lecturer, percent	27	44	0	185,570
Assistant professor, percent	21	41	0	185,570
Full professor, percent	37	48	0	185,570
Administrator professor, percent	15	36	0	185,570
Lecturer salary (2021 USD)	31,650	25,825	27,474	49,637
Assistant salary (2021 USD)	77,075	38,078	73,387	39,051
Full salary (2021 USD)	109,535	48,949	100,044	68,243
Administrator salary (2021 USD)	119,462	61,377	107,824	28,639
All salary (2021 USD)	83,403	55,881	78,969	185,570
Lecturer benefits (2021 USD)	2,351	6,458	0	49,637
Assistant benefits (2021 USD)	2,964	7,092	0	39,051
Full benefits (2021 USD)	6,736	13,654	0	68,243
Administrator benefits (2021 USD)	3,607	15,976	0	28,639
All benefits (2021 USD)	4,286	11,547	0	185,570

sity, Eastern Illinois University, Governors State University, Illinois State University, Northeastern Illinois University, Northern Illinois University, Southern Illinois University (all five campuses), University of Illinois (all four campuses), Western Illinois University.

[12] The reasons for restricting to the sample with identified year of hire in the range 2011-2021 is explained in subsection 2.3.

1.2 Trends in Finances, Enrollment, and Faculty Composition

A state government in the US plans an annual budget a couple of years ahead of the fiscal year, with the legislature approving a budget request put forth by the governor's office.[13] This process leads to yearly variation in state appropriations not seen in other revenues sources (such as federal government appropriations), since US states differ in their rate of (financial) support for higher education, and are subject to fiscal constraints. US states governments, by majority, are legally obligated to run a balanced-budget, so that yearly variation in tax revenues (caused by changing economic conditions or otherwise) necessarily affect state expenditures. State appropriations to higher education are a particularly attractive area of state spending to absorb such shocks to state finances (Delaney & Doyle 2011).[14] Additionally, there is yearly state variation in the number of higher education students (Turner 2014), so that per-student state appropriations vary on multiple dimensions.

Figure 1 exhibits the trends for the mean of US public universities between the years 1990-2021. We see a rise in total revenues received by public universities (from all sources), and a notable increase in mean tuition revenues from \$48 million per year-university to \$150 million per year-university. Non-institutional revenues refer to revenues coming from external sources, not raised by internal university activities;[15] non-institutional revenues rose over this time period almost exclusively thanks to the rise in tuition revenues. At the same time, total state appropriations stagnated at around \$100 million per year-university for 1990-2008, fell slightly around 2008 and have not recovered. While public universities experienced a

[13] Deming & Walters (2017) present a full discussion of the state appropriation decision-making process, drawing on administrative records originally analysed by Parmley, Bell, L'Orange & Lingenfelter (2009).

[14] Delaney & Doyle (2011) fully describes the financial environment of state expenditures, and what makes spending on higher education an attractive area for state governments to expand funding during years of higher tax revenues, and retract funding in leaner years. An analysis of state expenditures for the years 1980-2004 (overlapping with the sample for this analysis) provides solid evidence for these trends.

[15] US universities raise revenues from many internal activities, including sales of nondegree related educational courses to publishing deals. The non-institutional revenue measure is constructed to consider only revenues resulting from external decisions, including state, local, and federal appropriations and tuition revenues. Rates of tuition are considered external since most state governments play a large role in deciding tuition rices for public universities (Deming & Walters 2017).

financial stagnation, private universities were not exposed to the same constraints, receiving \$37,000 per student in 1990 and \$49,000 in 2021 with no corresponding decline in any specific component.

Figure 1: Mean Total Revenues among Public Universities, by Year.

(a) Total, millions \$ 2021 CPI-U. **(b)** Per Enrolled Student, \$ 2021 CPI-U.

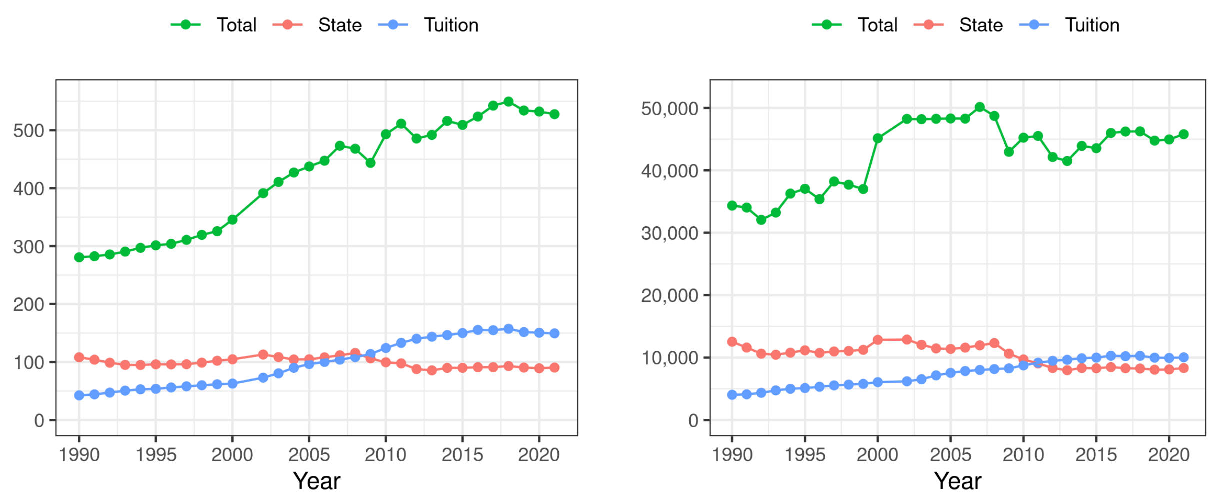
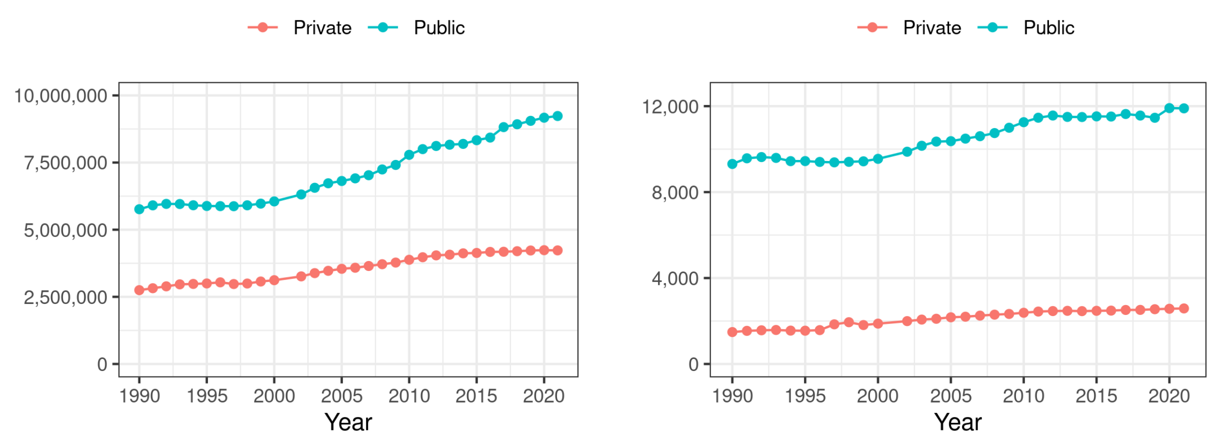


Figure 2: Total Student Enrollment, by University Sector, and Year.

(a) Total. **(b)** Mean, University Level.



At the same time, student enrollment at public universities rose precipitously. 6.2 million students were enrolled in public universities in 1990, and this number rose by 47% to 9.1 million, with most of the increase occurring over the years 2000-2021. Figure 2 shows that total enrollment at public universities has also risen over the same time period, but not as drastic in either relative or absolute terms; the mean public university also grew over this time period, from 9,800 students in 1990 to 11,800 in 2021. This means that per student mean revenues per student (seen in Figure 1b) have stagnated across all measures, and particularly fallen from $11,000 per student in 1990 to less than $8,000 per student in 2021.

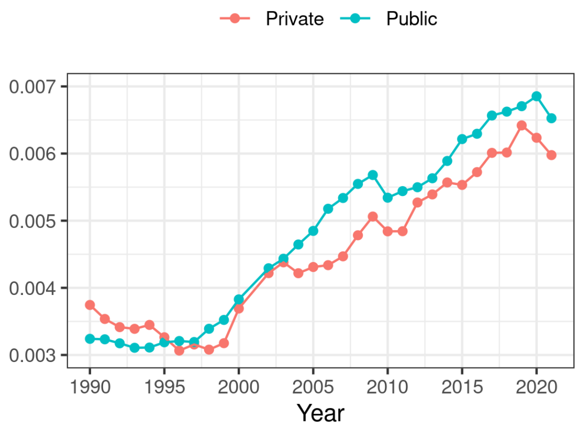
Figure 3 documents the divergence in faculty composition (per student) between the average private and public university 1990-2021. Public universities start with a higher baseline of around 4.5 professors per 100 students, and exhibits yearly variation of less than 0.5 professor per 100 students over the thirty years. Public universities start with 3.9 professors per student, and this number falls to 3.5 primarily in the 2008-2011 time period. We see a similar difference in baseline, and fall for the years 2008-2011 for assistant professors. Private and public universities have similar numbers of associated and full professors before the year 2000, yet this number has fallen by over 20% in the next 20 years only for public universities: in 2021 the mean PU has 6 fewer full professors per student than the mean private university. At the same time period, we see the rise in use of non-tenure track instructor positions (referred to as lecturers from here on), who were employed at similar rates in both sectors in 1990 yet have been utilised by public universities at a higher rate since.

1.3 Trends in Illinois

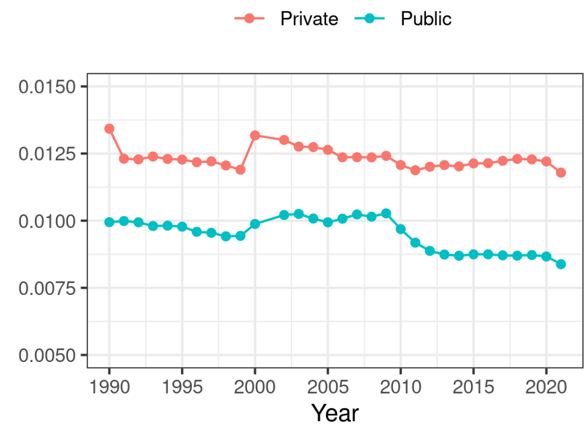
The state of Illinois particularly exemplifies the stagnation in state support for higher education that the rest of the nation has experienced 1990-2021. Figure 4 shows the trends for revenues among the seven Illinois public university campuses, including the falling share of

Figure 3: Total Professor Count per Student, by University Sector, Professor Appointment, and Year.

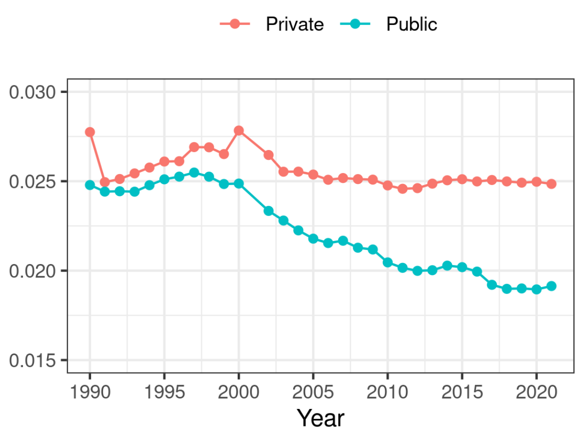
(a) Lecturer



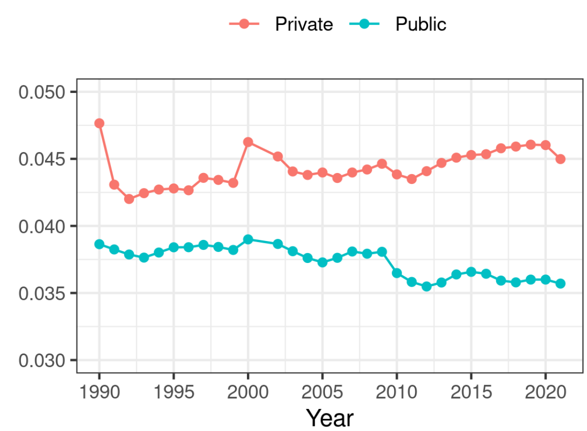
(b) Assistant.



(c) Full.



(d) All.

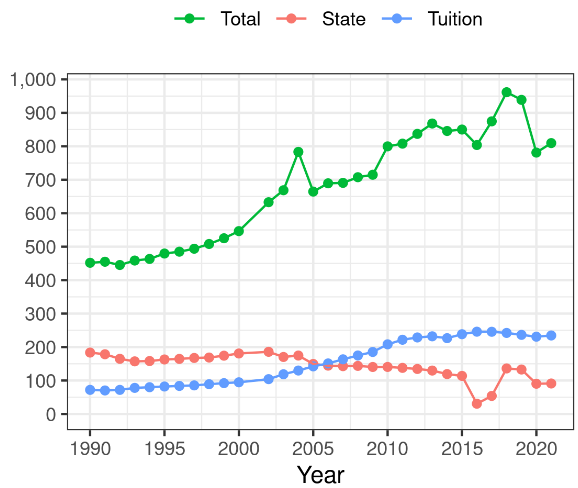


state appropriations and substitution towards tuition revenue.

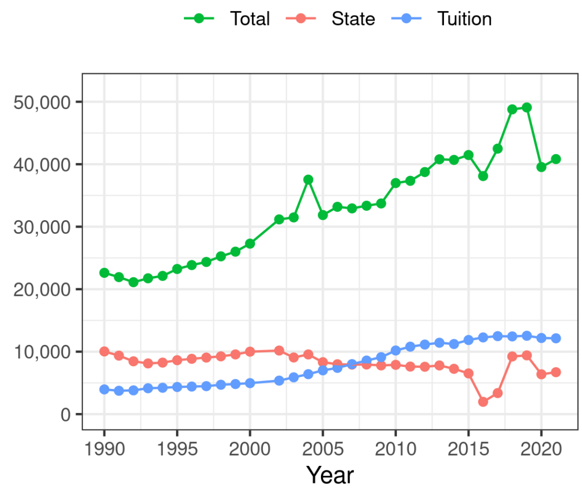
The decade of 2010-2021 has also seen yearly variation in its revenues, particularly around 2016. In the calendar year 2015 partisan disagreements between the democratic legislature and republican governor led to the 2016 fiscal year starting with no state budget. State agencies, and higher education institutions, employed accounting tehniques to continue operation.[16]

[16]Fiscal year 2016 refers to June 205 to June 2016, as is the same for the academic year definition in this

Figure 4: Mean Revenues among Illinois Public Universities, by Year.



(a) Total, millions $ 2021 CPI-U.



(b) Per Enrolled Student, $ 2021 CPI-U.

While state institutions continued to operate, there were drastic revenue and spending cuts in response to the budget impasse, as it continued through fiscal year 2017, and ended with a new budget restoring revenues to state agencies and universities for the 2018 fiscal year. This variation in public university revenues, stemming entirely from political disagreements — not from state decisions regarding higher education and its finances (Young, Wiley & Searing 2020) — via the state appropriations channel, mean that Illinois public universities exhibit sizable changes in their state appropriations over 2011-2021, of similar order to those for the rest of the country over 1990-2021.

1.4 University Responses to Financial Shocks

Subsection describing how a university may respond to shocks on its sources of revenues. Cite other papers on how this went.

analysis. K-12 schools were unaffected thanks to a separate budget agreement allowing non-higher education to operate as before.

Write about shocks in state appropriations primarily here.

Additional paragraph on how the incumbent professors may be affected.

2 Empirical Framework

A professor is employed by a university, so it stands to reason that when public universities experience a secular fall in revenue — analogous to a demand shock in the private sector — that their human resources decisions will be affected. Universities have been shown to freeze faculty hiring and general faculty salaries in response to financial shocks, such as the Great Recession (Turner 2014).

Shock to state appropriations only, as shocks to total revenues/spending requires identification for multiple sources. Tuition is an outcome of changes in the state appropriations, so discuss whether it is an outcome or a control. Leave footnote that results are relatively similar, so leave out this control.

Naïvely we can analyse the relationship between professor-outcomes $Y_{i,t}$ at university i in year t as a result of university revenues per student $X_{i,t}$. The exact measure of university revenues, X_{it} is non-institutional revenues, the sum of university funding from outside sources – local, federal, and state appropriations plus tuition revenue.[17] Outcomes include count of professors per student, and average salary, within each university-year. This model gives β the association with these outcomes and university revenues per student,[18] including fixed effects to control for effects specific to the university and year. Log(.) transforming the variables improves the interpretability of β as an elasticity for professor count per student

[17] This measure is in line with the Chakrabarti et al. (2020) approach of considering revenues from the state, but does not ignore yearly changes in revenues arising from tuition revenues – which are shown to be heavily related.

[18] Note that dividing by student count also implicitly controls for the size of the university, so that this model accounts for yearly variation in professor count and university revenues arising from growth in a university.

with respect to university revenues.

$$Y_{i,t} = \alpha_i + \gamma_t + \beta X_{i,t} + \epsilon_{i,t} \tag{1}$$

And yet a university's finances are not exogenous to decisions made by the university administrator (such as hiring), state outcomes or enrollment. Instead, the state government and university administration undertake a complex process of alloting resources across multiple different priorities, including instruction, research, or between departments. Importantly for this analysis, revenues received from a PU's state government provide opportunity to address this endogeneity.

2.1 State Appropriation Shocks

Deming & Walters (2017), Chakrabarti et al. (2018, 2020) address endogeneity in PU finances by exploiting a shift-share instrument for changes in state-level funding interacted with university reliance on state funding in a base period. The system exploits the fact that institutions who rely on state appropriations more will be affected by state appropriation shocks. We start with the shift-share instrument.

$$Z_{i,t} := \log\left[\left(\frac{\text{Total State Funding}_{s(i),t}}{\text{Student Population}_{s(i),t}}\right)\sum_{\tau=0}^{3}\frac{1}{4}\left(\frac{\text{State Funding}_{i,1990+\tau}}{\text{Total Revenues}_{i,1990+\tau}}\right)\right] \tag{2}$$

$Z_{i,t}$ is the instrument for (log) state appropriations for institution i in year t, interacting the average funding for university i in state $s(i)$ with reliance on state funding relative to total revenues, averaged across the base years 1990–1993.[19] Chakrabarti et al. (2020) notes the tendency for public universities to respond to state funding cuts by increasing reliance

[19] 1990–1993 are defined as data for PU finance data are most comparable (i.e. without many missing values) beginning in 1990. Deming & Walters (2017) use the single year 1990 as the base year, though I use the four years to ameliorate missing values in the single year of 1990. Results are similar in either specification.

on tuition, where Deming & Walters (2017) specifically instruments for tuition revenues with collected information on legislative tuition price controls. As such, it is important in my set-up to explicitly control for tuition revenues in the first-stage.

The first-stage is then as follows, including institution and year fixed effects.

$$X_{i,t} = \eta_i + \zeta_t + \delta Z_{i,t} + \epsilon_{i,t} \tag{3}$$

We note the conditions for exogeneity in the instrument (following the discussion presented by Chakrabarti et al. 2020). The instrument is exogenous if state policy decisions for funding of, or tuition charges by public universities, are uncorrelated with unobserved changes in the expenditures of any specific college or university in the state. This assumption is plausible given that the majority of states have multiple (i.e. more than five) public universities, without any single university campus receiving the majority of state funding within any single state. Secondly, addressing endogeneity in university revenues by the shift-share identification strategy requires exogeneity in either the base-line share or shift component of the instrument. In this case, we satisfy the second: universities' institutional-level decisions are not correlated with contemporaneous or upcoming shocks to state appropriations.[20]

Table 3 presents results of the first-stage regression, separately with and without the tuition control and fixed effects, at the institution level (i.e. using IPEDS data).[21] We note columns (1) and (2) estimate that a shock to state appropriations per student in the state of 10% is associated with around 2.5% change in non-institutional revenues per student at the university; the instrument is strong, and we note similarity in estimates with and without inclusion of fixed effects. Columns (3) and (4) exclude the tuition revenue control (explained above) to exhibit bias in the first-stage if it is not controlled for. Column (3) shows similar

[20]It would be plausible to consider the case that universities make institutional-level decisions in a consistently different manner to those with differing reliance on state appropriations in 1990, so that exogeneity by the base-line share is not plausible here.

[21]Representations for frequentist significance levels (i.e. 10, 5, 1% etc.) are omitted here, and in all following tables.

Table 3: First Stage Estimates, for University Revenues by Appropriation Shock.

	Dependent Variable: State Funding			
	(1)	(2)	(3)	(4)
Appropriations Shock	0.990	0.608	0.980	0.350
	(0.075)	(0.059)	(0.078)	(0.084)
Tuition Revenue	0.063	0.558		
	(0.055)	(0.059)		
Constant		−0.982		6.011
		(0.751)		(0.688)
Uni. + Year fixed effects?	Yes	No	Yes	No
F stat.	92.461	88.72	156.791	17.487
Observations	18,504	18,504	18,504	18,504
R^2	0.801	0.222	0.801	0.064

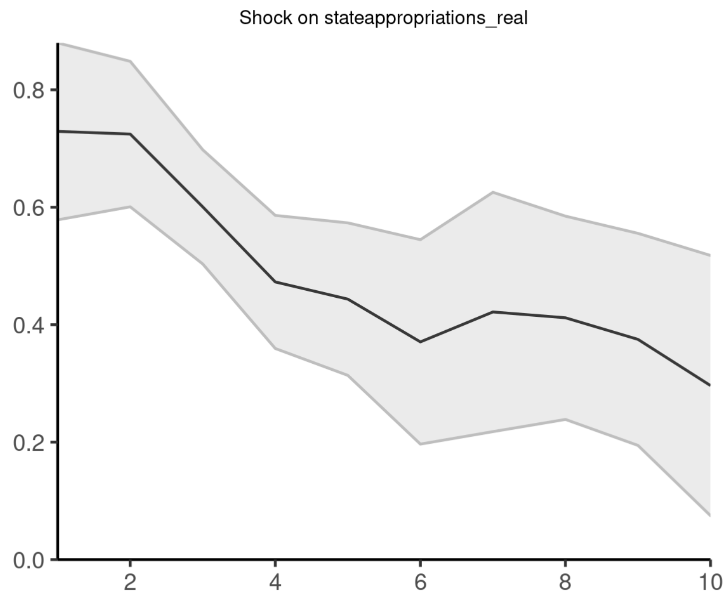
Note: Standard errors are clustered at the state-year level.

estimates to columns (1), (2) thanks to inclusion of fixed effects, so that the fixed effects was effective in soaking variation in per-student tuition revenues at the institution-year level. Column (4) exhibits the worst case, and extreme bias in the appropriation shock first-stage without the tuition control. Column (3) represents the estimates for Equation (3) with fixed effects, omitting the tuition revenue control, and is the preferred form that I proceed with in the following.

Figure 5 presents local projection estimates for the staying-power of the state appropriation shock to university revenues. We see the time 0 estimate coincides with that of Column (1) in Table 3, the contemporaneous effect of the shock revenues. We see a decaying, yet real and positive, effect of the shock on revenues for the next 5 years, illustrating the staying power of the effect.

These results, together with the case for exogeneity, show the appropriations shock instrument strongly predicts university revenues in the first-stage estimation.

Figure 5: Local Projection Estimates for First-Stage Equation (3).



2.2 Instrumental Variables Model, University-Level

The primary empirical model combines the instrumental variable for state appropriation shocks with the empirical model for the effects of university revenues at the university-level — i.e. parameter β in the following.[22]

$$X_{i,t} = \eta_i + \zeta_t + \delta Z_{i,t} + \epsilon_{i,t} \tag{4}$$

$$Y_{i,t} = \alpha_i + \gamma_t + \beta \widehat{X}_{i,t} + \varepsilon_{i,t} \tag{5}$$

I estimate the system by two stage least squares, including institution and year fixed effects, and investigate outcomes at the university-level to analyse effects on the university as a result of changes in revenues. Additionally, I estimate the model via local projections (Jordá

[22]It is important to note the treatment effect isolated here; the instrumental variables approach identifies the local average treatment effects (LATE) specific to the instrument. So we interpret this treatment effect as a university's response in employment count and average salaries to revenue changes, changes specific to state appropriation shocks, among the complier group — i.e. universities with any exposure to shocks, assuming no universities increase employment or salaries in response to negative revenue shocks. Mogstad, Torgovitsky & Walters (2021) provide a full discussion of the LATE with instruments and multiple monotonicity conditions.

2005, Basso, Miller & Schaller 2022) to investigate whether the effects of revenues on faculty composition linger for multiple years after the original appropriation shock. Regarding outcomes, I focus on the composition of the professors employed at the university by analysing (log) count per student, and average salaries paid to, professors employed by the university.

Figure 6: Instrument Variables Model for University Finances and Faculty Composition.

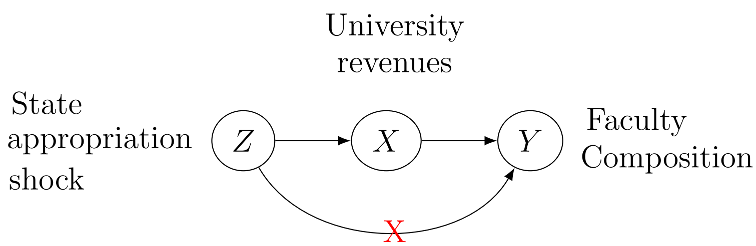


Figure 6 presents the system in graphical form, for the causal effect of state appropriation shocks on university revenues and thus faculty composition.

2.3 Instrumental Variables Model, Individual Professor-Level

This analysis additionally uses data regarding individual professors in the Illinois university system, to investigate the effects of changes in university revenues on the individual professors at the universities. Redefining the level of outcome requires adjustment to the empirical approach to leverage variation in university finances for the years following when a professor joins the university.[23]

Equation (6) defines a rolling-share variant of the instrument, $\widetilde{Z}_{j,t}$, where the university's state appropriations share exposure is based in the year a professor joins the university — and not the base period 1990–1993. j indexes each professor in year t, $\tau(j)$ for the year the

[23]This formulation follows that presented by Chakrabarti et al. (2020), where individual student outcomes are analysed via variation in state appropriations after their freshman-year. This contrasts with subsection 2.2 and Deming & Walters (2017), where the unit of analysis is the university-year.

professor first joins their Illinois PU.[24]

$$\widetilde{Z}_{j,t} \coloneqq \log\left[\left(\frac{\text{Total State Funding}_{s(j),t}}{\text{Student Population}_{s(j),t}}\right)\left(\frac{\text{State Funding}_{\tau(j)}}{\text{Total Revenues}_{i,\tau(j)}}\right)\right] \tag{6}$$

This approach leverages an insight, made available by level of the data: that an individual professor is effected by changes in university revenues after they have joined the university.[25] Exogeneity and relevance of the rolling-share instrument, $\widetilde{Z}_{j,t}$, follows the same reasoning as that for the base-share instrument, $Z_{i,t}$, discussed in subsection 2.1.[26] We satisfy the assumptions for exogeneity by noting that none of the Illinois public campuses take the majority of state appropriations, and that the instrument identification strategy relies on exogeneity in changes in state appropriations to individual professor-outcomes, following the year they joined the university.[27] Table A2 presents results of the first stage estimation, showing that the instrument is strong (after conditioning on tuition revenues) in the same way as that for the university-level outcomes (Table 3), with very similar estimates for the association between appropriation shocks and non-institutional revenues.

The full model is defined as follows where $i(j)$ refers to the institution that professor j is employed at, and $Y_{j,t}$ refers to individual-level outcomes total salary, rate of promotion, and propensity to leave the Illinois PU system. The system includes a fixed effect for the

[24]Identifying $\tau(j)$ is possible for j by restricting to all professors hired 2011-2021 — i.e. in the years after the start of the panel. It is not possible to discern the hiring year for professors who were hired in the years preceding 2011, and so the entire sample is only possible to analyse using the base-share in years 1990-1993 formulation (Table A5, A7).

[25]Notice that subsection 2.2 considers the number of professors employed by the university; whether a professor becomes employed at the university is likely affected by that university's finances. The formulation in this section does not consider whether the professor joins the university, instead taking as given that the professor is employed at the university, and then projecting the effect on the individual given they are employed here.

[26]The base-share instrument is still used for some outcomes with the individual Illinois professors, where appropriate (Table A5, Table A7).

[27]Additionally, within-institution changes resulting from share reliance on state funding may be correlated with unobserved changes in the outcomes, so that Chakrabarti et al. (2020) note the importance of controlling for the base share and state student population. The formulation here implicitly controls for these factors via the fixed effects; results are relatively similar while including these controls without including fixed effects.

institution and first year of employment.[28]

$$X_{i(j),t} = \theta_{i(j)} + \phi_{\tau(j)} + \delta \widetilde{Z}_{i(j),t} + \kappa W_{i(j),t} + \epsilon_{i(j),t} \quad (7)$$

$$Y_{j,t} = \mu_{i(j)} + \nu_{\tau(j)} + \beta \widehat{X}_{i(j),t} + \lambda W_{i(j),t} + \varepsilon_{i(j),t} \quad (8)$$

We then interpret parameter β in this formulation as the effect of changes in university revenues, via state appropriation shocks, on an individual professor.

3 Results

3.1 University-Level

Table 4 presents OLS and IV estimates, where the outcome is (log) count of professors employed at the university, separated by group and combined (columns 7, 8). Within each group we see a positive correlation between university revenues and professor count per student (the OLS columns), where an increase in university total revenues by 10% is associated with an increase in professor employment count between 3.5-4.5%. Lecturers per student is not shown to be correlated with total univesity revenues. The 2SLS columns show results after identifying university revenues with the appropriation shock. All professor count per student increases by 3% in response to a 10% rise in total revenues, mediated by revenue shocks. The effect is driven by increases in the count of assistant and full professors (i.e. tenure-track and tenured) per student, where assistant professor count per student increase by 6.7%, and full professor 5%. The count of lecturers per student decreases by 12% in response to a (positive) 10% shock in university revenues.

Figure 7 shows local projection estimates, where the effect on total professor count per

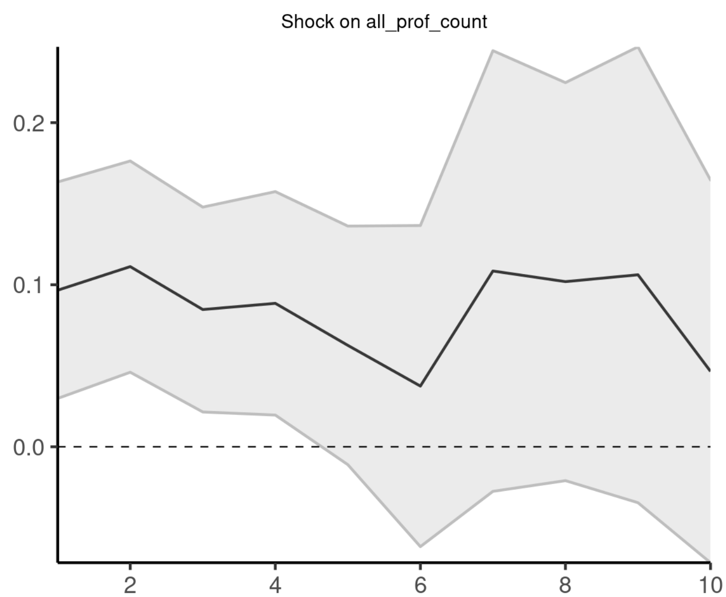
[28]The instrument varies by institution, based in the year of first employment so that these are the corresponding fixed effects and levels of clustered standard errors.

Table 4: OLS and 2SLS Estimates for University Faculty Composition.

	Dependent Variable: Employment Count by Professor Group							
	Lecturer		Assistant		Full		All	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
State Funding	−0.129	−0.437	0.086	0.136	0.128	0.120	0.083	0.053
	(0.030)	(0.101)	(0.044)	(0.075)	(0.058)	(0.037)	(0.047)	(0.031)
Observations	17,329	17,329	17,826	17,826	17,929	17,929	18,504	18,504
R^2	0.671	0.657	0.709	0.708	0.783	0.783	0.812	0.812

Note: Standard errors are clustered at the state-year level.

Figure 7: Local Projection Estimates for Professor Count per Student.



student persists at the same magnitude of 0.3 four years after the identified shock. These findings are in line with Turner (2014) observing that universities froze hiring particularly for tenure-track positions in response to negative budget shocks in the late 2000s, and Brown et al. (2014) from shocks to university endowments. We see a negative coefficient for the number of lecturers per student. This effect lines up with two trends we see in subsection 1.2:

that public universities revenues (per student) are decreasing while utilisation of non-tenure track lecturers increased over the same time period. And yet, identifying the university revenues by the state appropriations shock increases the magnitude of the effect (Column 2) with respect to the association (Column 1), increasing evidence that the two trends are causally linked. Between years 1990-1999 IPEDS provided count of professors by explicit tenure designation (opposed to named position as in Table 4), and Table A3 presents results of the respective regressions by tenure status. Results are relatively similar, yet imprecise from the much smaller number of observations.

Together these findings imply that public universities increase their count of tenure-track and tenured professors per student in years where revenues are more plentiful, by increasing hiring intensity and efforts to maintain incumbent professors. Yet, when revenues are not so bountiful, count of tenure-track and tenured professors per student decreases. At the same time, public university enrollment secularly increased over this time period, so that the universities satisfied their teaching obligations with non-tenure track lecturers. The mechanism that explains the changes in faculty composition are, however, not clear at this unit of analysis; individual data are needed to delve deeper.

3.2 Individual Professor Outcomes

I first examine whether a shock to the university's revenues affects the salaries of professors at the university. The first outcome is first-year salary for each professor by their position; Table 5 presents 2SLS estimates for the elasticity of total salaries with respect to university revenues, among the sample with a year of starting employment after 2010. New hires of assistant, full, or administrative position professors are not realted to revenues, via a shock to appropriations in their first-year of employment. Yet, we see the starting salary of lecturers is 3.8% higher given an increase in their hiring university's state funding.

Regarding total salary for every year of employment, Table 6 presents estimates for the

Table 5: 2SLS Estimates for Faculty Salaries, in First-Year, at Illinois Universities.

	Dependent Variable: Salaries by Professor Group				
	Lecturer	Assistant	Full	Admin	All
	(1)	(2)	(3)	(4)	(5)
State Funding	0.384	−0.256	−0.378	−0.130	0.238
	(0.158)	(0.212)	(0.313)	(0.331)	(0.196)
Observations	8,786	5,090	1,248	3,153	18,277
R^2	0.303	0.075	0.100	0.250	0.223

Note: Standard errors are clustered at the institution and first year of employment level.

elasticity of total salary with respect to university revenues, for the entire sample of professors hired after 2010.[29] The elasticity is non-distinguishable from zero among any group, which implies that long-term salaries are not related to university revenues. Table A5 presents the same model, for the sample of all professors and using the instrument based in years 1990-1993, similarly finding no relationship.

Table 6: 2SLS Estimates for Faculty Salaries at Illinois Universities.

	Dependent Variable: Salaries by Professor Group				
	Lecturer	Assistant	Full	Admin	All
	(1)	(2)	(3)	(4)	(5)
State Funding	0.009	−0.072	−0.044	−0.013	−0.011
	(0.094)	(0.040)	(0.038)	(0.049)	(0.086)
Observations	25,820	22,156	9,001	11,472	68,449
R^2	0.217	0.051	0.074	0.143	0.161

Note: Standard errors are clustered at the institution-year level.

Note that professor position (assistant, associate, full) is also an outcome, thanks to the promotion channel: a university may be less able to promote their professors to higher

[29] Recall that this is a subsample of the entire data, that the rolling shift-share instrument is only defined for the sample with an observed hiring date in the years 2011-2021.

paying positions when their revenues are constrained. Table A6 shows estimates where the outcome is rate of promotion within each professor group. The lecturer group describes the sample of professors who were ever listed as a non-tenure track lecturer and the binary for promotion equals one in a year they achieved an assistant professor position; assistant the same for the assistant to associate professor promotion; associate same for associate to full promotion. There is no discernible relationship between revenues and promotion among any position group.[30] Furthermore, local projection estimates (Figure A3) show that the there is no promotion effect, among all professors, for any of the following years. Lastly, Table A8, A9 describes estimates for rate of exit from the employing university among Illinois professors, and finds no relationship with university revenues.

3.3 Discussion

The results suggest that the recent stagnation in public university revenues per student has affected the composition of faculty within a university, away from professors tenured and on the tenure-track and towards non-tenured lecturers. At the same time, there are little discernible effects on individual professors hired in the years 2011-2021 at Illinois public universities, except for the salaries of first year lecturers. The rate that faculty leave their university, and their rate of promotion between positions, are unaffected by the university revenues, so this leaves one primary channel to explain changes in faculty composition: hiring.

Turner (2014) documents the wide-spread practice of hiring freezes at universities in response to budget shocks around the 2008 recession. Throughout the last decade, multiple such measures were taken by Illinois public universities in response to their deteriorating finances (Employee Relations and Human Resources at the University of Illinois 2010). The University of Illinois[31] did not receive the allocated state appropriations from the state of

[30] Table A7 shows estimates using the base-year instrument among the entire sample, finding the same results.

[31] The University of Illinois includes three public university campuses: Urbana-Champaign, Chicago, Springfield.

Illinois on time, so enacted cost-cutting measures to stay fiscally solvent. The university system placed a hold on all hiring for filling state-funded positions and promotions. Faculty were furloughed (placed on leave without pay) for a day each month, and university administrators placed on two days per month furlough, or eligible university employees could accept a voluntary, equivalent pay reduction. The University of Western Illinois adopted very similar measures in response to the Illinois budget crisis in 2016-2017 (University Communications at Western Illinois University 2016).

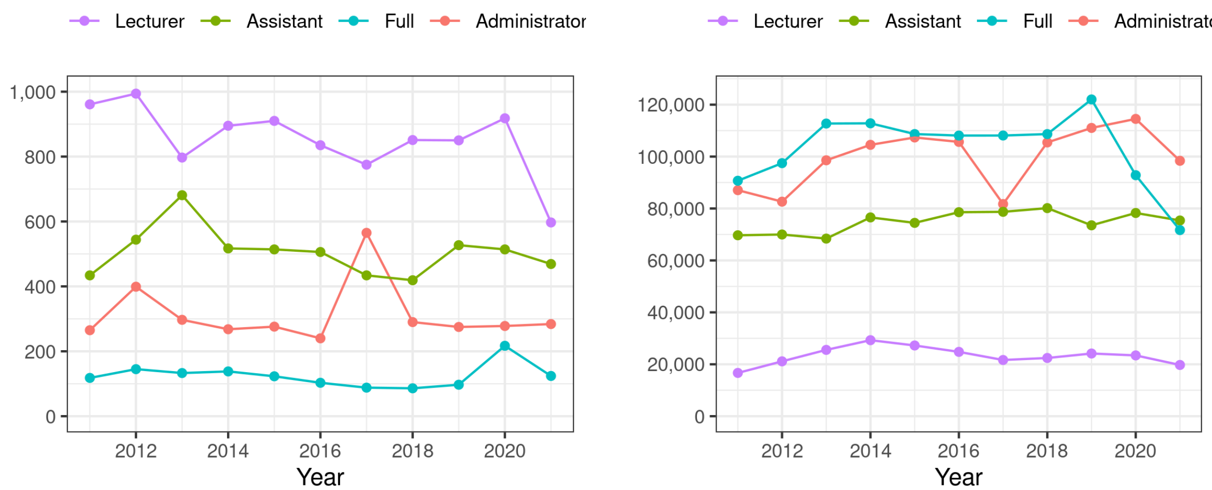
These examples show that the Illinois state universities attempted to affect each of the professor outcomes investigated in section 3, yet the only measurable affect was on count of professor per student (implied via slower hiring), and first-year lecturer salaries. To investigate these trends for the entire state, Figure 8 shows the count of professors hired in the years 2011-2021, and their mean salary, by position. In particular, no position had sustained rises in hiring while enrollment within the university was rising (so that new hires per student necessarily fell), and hiring of new administrators jumped once the Illinois budget crisis ended in 2017. At the same time, professor new hires' starting salaries remained relatively constant for lecturer and assistant professors, yet rose and fell over the decade for full professors and administrators.

While costs education have been rising in the US, thanks to multiple overlapping trends (Ehrenberg 2012), public universities have also had to deal with declining state support. It is natural to expect that such headwinds will lead to systematic change at public universities, changes which are not neutral on the professors they employ, or to their goals of research and providing education. Furthermore, private universities in this country are not exposed to these same financial headwinds. If public universities' hiring of faculty is disrupted by changes in state appropriations, then we can expect that private universities will benefit (in a competitive sense) by being able to hire better professors from relatively resource constrained public universities. While public universities continue to educate the majority of higher

Figure 8: Trends in New Hires at Illinois Public Universities 2011-2021.

(a) New Hire Count, Total.

(b) Mean Salary in First Year for New Hires, $ 2021 CPI-U.



education students in the US, and disproportionately students from low-income backgrounds and minorities, we should worry about the effects that restricting their financial support has on the composition of distribution of higher education and research in this country.

4 Summary and Concluding Remarks

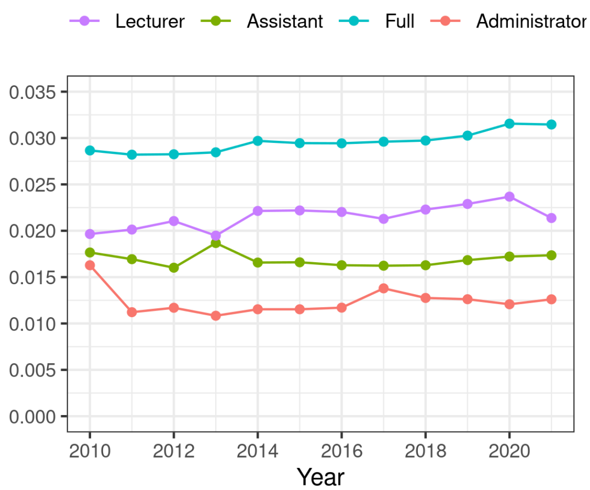
A few paragraphs conclusion go here.

References

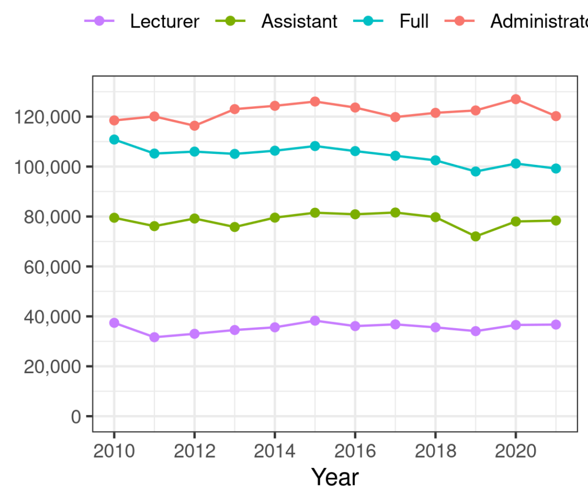
Abe, Y., Watanabe, S. P. et al. (2015), 'Implications of university resource allocation under limited internal adjustability', *Theoretical Economics Letters* **5**(05), 637. https://doi.org/10.4236/tel.2015.55074. 3

Figure 9: Faculty Profile at Illinois Public Universities 2011-2021.

(a) Faculty Count per Enrolled Student, Total for the State.



(b) Mean Salary for All Faculty, $ 2021 CPI-U.



Adämmer, P. (2019), 'lpirfs: An R Package to Estimate Impulse Response Functions by Local Projections', *The R Journal* **11**(2), 421–438. https://doi.org/10.32614/RJ-2019-052. 32

American Association of University Professors (2021), *2020-21 Faculty Compensation Survey Results*. https://www.aaup.org/2020-21-faculty-compensation-survey-results. 6

Angrist, J. D. & Lavy, V. (1999), 'Using maimonides' rule to estimate the effect of class size on scholastic achievement', *The Quarterly journal of economics* **114**(2), 533–575. https://doi.org/10.1162/003355399556061. 4

Bandiera, O., Larcinese, V. & Rasul, I. (2010), 'Heterogeneous class size effects: New evidence from a panel of university students', *The Economic Journal* **120**(549), 1365–1398. https://doi.org/10.1111/j.1468-0297.2010.02364.x. 4

Basso, G., Miller, D. & Schaller, J. (2022), Dynamic treatment effects for empirical microeconomists: Local projections and quasi-experimental research designs, Working paper. 18

Bettinger, E. P. & Long, B. T. (2010), 'Does cheaper mean better? the impact of using adjunct instructors on student outcomes', *The Review of Economics and Statistics* **92**(3), 598–613. https://doi.org/10.1162/REST_a_00014. 4

Bound, J., Braga, B., Khanna, G. & Turner, S. (2019), 'Public universities: The supply side of building a skilled workforce', *RSF: The Russell Sage Foundation Journal of the Social Sciences* **5**(5), 43–66. https://www.rsfjournal.org/content/5/5/43. 3

Bound, J. & Turner, S. (2007), 'Cohort crowding: How resources affect collegiate attainment', *Journal of public Economics* **91**(5-6), 877–899. https://doi.org/10.1016/j.jpubeco.2006.07.006. 3

Brown, J. R., Dimmock, S. G., Kang, J.-K. & Weisbenner, S. J. (2014), 'How university endowments respond to financial market shocks: Evidence and implications', *American Economic Review* **104**(3), 931–62. https://doi.org/10.1257/aer.104.3.931. 3, 21

Chakrabarti, R., Gorton, N. & Lovenheim, M. F. (2018), The effect of state funding for postsecondary education on long-run student outcomes, *in* 'IZA World Labor Conference, Institute of Labor Economics (Berlin June 2018)', pp. 28–29. 3, 14

Chakrabarti, R., Gorton, N. & Lovenheim, M. F. (2020), State investment in higher education: Effects on human capital formation, student debt, and long-term financial outcomes of students, Working Paper 27885, National Bureau of Economic Research. https://doi.org/10.3386/w27885. 1, 2, 3, 4, 5, 13, 14, 15, 18, 19

Courant, P. N. & Turner, S. (2019), *Faculty Deployment in Research Universities*, in 'Productivity in Higher Education, University of Chicago Press', pp. 177–208. http://www.nber.org/chapters/c13879. 3

Delaney, J. A. & Doyle, W. R. (2011), 'State spending on higher education: Testing the balance wheel over time', *Journal of Education Finance* pp. 343–368. https://doi.org/10.1007/s11162-013-9319-2. 8

Deming, D. J. & Walters, C. R. (2017), The impact of price caps and spending cuts on u.s. postsecondary attainment, Working Paper 23736, National Bureau of Economic Research. https://doi.org/10.3386/w23736. 1, 2, 4, 5, 8, 14, 15, 18

Ehrenberg, R. G. (2012), American higher education in transition, Vol. 26, pp. 193–216. https://doi.org/10.1257/jep.26.1.193. 25

Ehrenberg, R. G. & Zhang, L. (2005), 'Do tenured and tenure-track faculty matter?', *Journal of Human Resources* **40**(3), 647–659. https://doi.org/10.3368/jhr.XL.3.647. 4

Employee Relations and Human Resources at the University of Illinois (2010), Furloughs, voluntary pay reduction program and hiring freeze information, Technical report. https://nessie.uihr.uillinois.edu/pdf/HR_Services-Furlough-and-Hiring-Freeze-Webinar-2010-01-22.pdf. 24

Figlio, D. N., Schapiro, M. O. & Soter, K. B. (2015), 'Are tenure track professors better teachers?', *Review of Economics and Statistics* **97**(4), 715–724. https://doi.org/10.1162/REST_a_00529. 4

Gaure, S. (2013), 'lfe: Linear group fixed effects', *The R Journal* **5**(2), 104–117. https://journal.r-project.org/archive/2013/RJ-2013-031/RJ-2013-031.pdf. 32

Hemelt, S. W., Stange, K. M., Furquim, F., Simon, A. & Sawyer, J. E. (2021), 'Why is math cheaper than english? understanding cost differences in higher education', *Journal of Labor Economics* **39**(2), 397–435. https://doi.org/10.1086/709535. 3

Hlavac, M. (2018), *stargazer: Well-Formatted Regression and Summary Statistics Tables*, Central European Labour Studies Institute (CELSI). R package version 5.2.2, https://CRAN.R-project.org/package=stargazer. 32

Illinois Board of Higher Education (2021). Public University Administrator and Faculty Salary and Benefits Database, accessed 10 January 2022. https://salarysearch.ibhe.org/. 5

Johnson, W. R. & Turner, S. (2009), 'Faculty without students: Resource allocation in higher education', *Journal of Economic Perspectives* **23**(2), 169–89. https://doi.org/10.1257/jep.23.2.169. 3

Jordá, O. (2005), 'Estimation and inference of impulse responses by local projections', *American Economic Review* **95**(1), 161–182. https://doi.org/10.1257/0002828053828518. 17, 32

Mogstad, M., Torgovitsky, A. & Walters, C. R. (2021), 'The causal interpretation of two-stage least squares with multiple instrumental variables', *American Economic Review* **111**(11), 3663–98. https://doi.org/10.1257/aer.20190221. 17

Mountjoy, J. (2022), 'Community colleges and upward mobility', *American Economic Review* **112**(8), 2580–2630. https://doi.org/10.1257/aer.20181756. 5

Parmley, K., Bell, A., L'Orange, H. & Lingenfelter, P. (2009), 'State budgeting for higher education in the united states', *Report, State Higher Education Executive Officers* . https://eric.ed.gov/?id=ED506284. 8

R Core Team (2022), *R: A Language and Environment for Statistical Computing*, R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/. 31

Turner, S. E. (2014), *The impact of the financial crisis on faculty labor markets, in 'How the Financial Crisis Affected Higher Education'*, University of Chicago Press, pp. 133–176. https://www.nber.org/chapters/c12863. 3, 8, 13, 21, 24

University Communications at Western Illinois University (2016), Western illinois university to cut $20 million 2/26/16], Technical report. http://www.wiu.edu/news/newsrelease_print.php?release_id=13379. 25

US Department of Education Integrated Postsecondary Education Data System (2021). Education Data Portal (Version 0.14.0), Urban Institute, accessed 10 January 2022. https://educationdata.urban.org/documentation/, made available under the ODC Attribution License https://opendatacommons.org/licenses/by/1-0/. 5

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L. D., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersen, T. L., Miller, E., Bache, S. M., Müller, K., Ooms, J., Robinson, D., Seidel, D. P., Spinu, V., Takahashi, K., Vaughan, D., Wilke, C., Woo, K. & Yutani, H. (2019), 'Welcome to the tidyverse', *Journal of Open Source Software* **4**(43), 1686. https://doi.org/10.21105/joss.01686. 31

Young, S. L., Wiley, K. K. & Searing, E. A. (2020), '"squandered in real time": How public management theory underestimated the public administration–politics dichotomy', *The American Review of Public Administration* **50**(6-7), 480–488. https://doi.org/10.1177/0275074020941669. 12

A Appendix

A number of statistical packages, for the *R* language (R Core Team 2022), made the empirical analysis for this paper possible.

- *Tidyverse* (Wickham, Averick, Bryan, Chang, McGowan, François, Grolemund, Hayes, Henry, Hester, Kuhn, Pedersen, Miller, Bache, Müller, Ooms, Robinson, Seidel, Spinu, Takahashi, Vaughan, Wilke, Woo & Yutani 2019) collected tools for data analysis in the R language.

- *LFE* (Gaure 2013) implemented linear fixed effect models, with instruments, crucial for the empirical estimation in section 2.
- *Stargazer* (Hlavac 2018) provided a method to efficiently convert empirical results into presentable output in LaTeX.
- *Lpirfs* (Adämmer 2019) implemented estimation of the Jordá (2005) local projections methods, with instrumental variables, crucial to the local projections estimates presented in this project.

A.1 First Stage Estimates, Individual Outcomes

Table A1: IBHED Summary Statistics, Entire Professor Panel 2010–2021.

Statistic	Mean	St. Dev.	Median	N
Lecturer, percent	38	48	0	68,449
Assistant professor, percent	32	47	0	68,449
Full professor, percent	13	34	0	68,449
Administrator professor, percent	17	37	0	68,449
Lecturer salary (2021 USD)	27,931	25,783	18,729	25,820
Assistant salary (2021 USD)	79,842	37,139	75,541	22,156
Full salary (2021 USD)	108,252	57,567	97,527	9,001
Administrator salary (2021 USD)	111,256	62,519	99,012	11,472
All salary (2021 USD)	69,261	54,443	65,954	68,449
Lecturer benefits (2021 USD)	1,930	6,951	0	25,820
Assistant benefits (2021 USD)	2,820	7,067	0	22,156
Full benefits (2021 USD)	5,892	13,476	0	9,001
Administrator benefits (2021 USD)	3,188	19,671	0	11,472
All benefits (2021 USD)	2,950	11,165	0	68,449

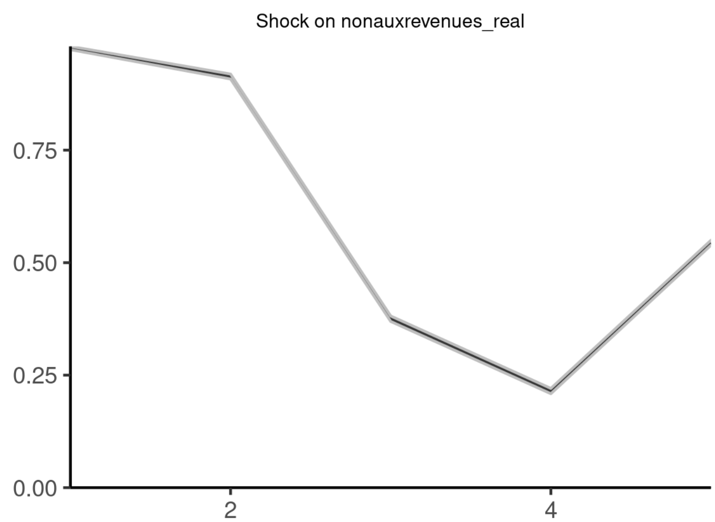
Note: This table presents the summary statistics for professors with an observed year of first-year at their university.

Table A2: First Stage Estimates, for Total University Revenues at the Individual-Level.

	Dependent Variable: State Funding			
	(1)	(2)	(3)	(4)
Appropriations Shock	0.939	0.486	0.920	0.328
	(0.024)	(0.084)	(0.024)	(0.066)
Tuition Revenue	0.711	0.766		
	(0.223)	(0.280)		
Constant		−1.906		6.484
		(2.827)		(0.549)
Fixed effects?	Yes	No	Yes	No
F stat.	754.498	17.745	1470.24	24.842
Observations	68,449	68,449	68,449	68,449
R^2	0.911	0.416	0.906	0.257

Note: Standard errors are clustered at the university-year level.

Figure A1: Local Projection Estimates for First-Stage Equation (7).



A.2 Additional Results, University-Level

Table A4 presents OLS and IV estimates where the outcome is (log) mean salary for professors employed at the university, separated by group. Similarly, Figure A2 shows the staying-power via projection methods. The outcome, mean salary is crude.

Table A3: OLS and 2SLS Estimates for University Faculty-Tenure Composition.

	Dependent Variable: Employment Count by Tenure Group							
	Non-tenure		Tenure-Track		Tenured		All	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
State Funding	−0.0004	1.499	0.048	1.926	0.051	0.267	0.037	0.893
	(0.016)	(10.764)	(0.051)	(8.050)	(0.029)	(1.104)	(0.023)	(4.610)
Observations	4,825	4,825	5,094	5,094	5,130	5,130	5,181	5,181
R^2	0.849	0.588	0.777	−0.413	0.898	0.872	0.932	0.426

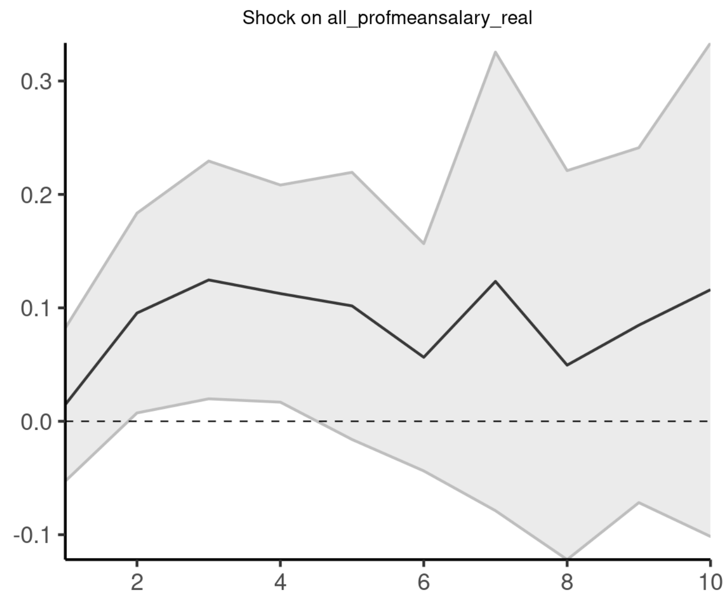
Note: Standard errors are clustered at the university-year level.

Table A4: OLS and 2SLS Estimates for University Faculty Salaries.

	Dependent Variable: Mean Salary by Professor Group							
	Lecturer		Assistant		Full		All	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
State Funding	0.010	0.034	0.007	0.011	0.011	0.027	0.004	0.018
	(0.005)	(0.025)	(0.006)	(0.021)	(0.005)	(0.029)	(0.011)	(0.035)
Observations	16,686	16,686	17,750	17,750	17,837	17,837	17,759	17,759
R^2	0.670	0.668	0.809	0.809	0.826	0.825	0.403	0.403

Note: Standard errors are clustered at the state-year level.

Figure A2: Local Projection Estimates for Professor Salary, Mean within Each University.



A.3 Additional Results, Individual-Professor Level

Table A5: 2SLS Estimates for Faculty Salaries at Illinois Universities.

	Dependent Variable: Salaries by Professor Group				
	Lecturer	Assistant	Full	Admin	All
	(1)	(2)	(3)	(4)	(5)
State Funding	−0.104	−0.022	−0.014	−0.050	−0.086
	(0.044)	(0.023)	(0.005)	(0.027)	(0.043)
Observations	49,637	39,051	68,243	28,639	185,570
R^2	0.184	0.062	0.078	0.127	0.138

Note: Standard errors are clustered at the institution-year level.

Table A6: 2SLS Estimates for Faculty Promotion Rate at Illinois Universities, using Rolling Instrument.

	Dependent Variable: Promotion Rate by Professor Group			
	Lecturer	Assistant	Associate	All
	(1)	(2)	(3)	(4)
State Funding	0.014	0.035	0.029	0.014
	(0.007)	(0.019)	(0.062)	(0.009)
Observations	16,346	17,094	4,377	42,396
R^2	0.007	0.024	0.029	0.009

Note: Standard errors are clustered at the institution and first year of employment level.

Table A7: 2SLS Estimates for Faculty Promotion Rate at Illinois Universities, using Base-Year Instrument.

	Dependent Variable: Promotion Rate by Professor Group			
	Lecturer	Assistant	Associate	All
	(1)	(2)	(3)	(4)
State Funding	0.015	0.020	0.009	0.002
	(0.008)	(0.009)	(0.012)	(0.003)
Observations	36,097	39,527	35,978	135,221
R^2	0.014	0.018	0.025	0.004

Note: Standard errors are clustered at the institution and first year of employment level.

Figure A3: Local Projection Estimates for Promotion Rate at Illinois Universities.

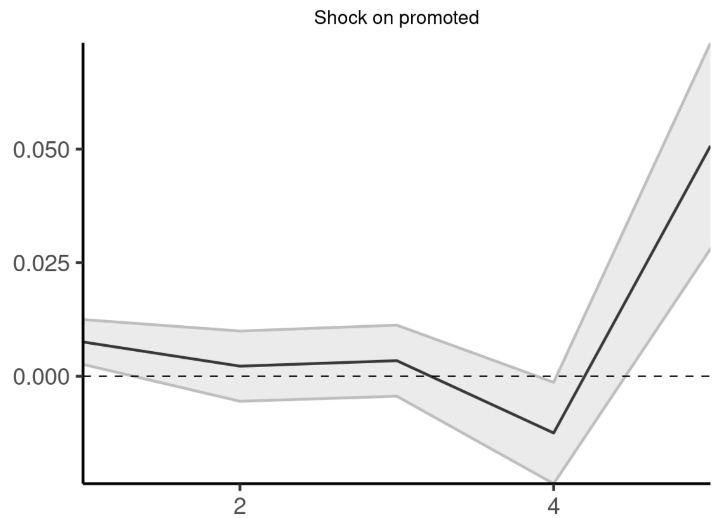


Table A8: 2SLS Estimates for Faculty Exit Rate at Illinois Universities, using Rolling Instrument.

	Dependent Variable: Exit rate by Professor Group				
	Lecturer	Assistant	Full	Admin	All
	(1)	(2)	(3)	(4)	(5)
State Funding	−0.007	0.002	−0.004	−0.003	−0.006
	(0.024)	(0.006)	(0.008)	(0.020)	(0.015)
Observations	23,376	19,757	7,190	10,191	60,514
R^2	0.013	0.006	0.014	0.068	0.016

Note: Standard errors are clustered at the institution and first year of employment level.

Table A9: 2SLS Estimates for Faculty Exit Rate at Illinois Universities, using Base-Year Instrument.

	Dependent Variable: Exit rate by Professor Group				
	Lecturer	Assistant	Full	Admin	All
	(1)	(2)	(3)	(4)	(5)
State Funding	−0.009	0.0001	0.001	0.018	0.004
	(0.015)	(0.003)	(0.003)	(0.020)	(0.009)
Observations	45,734	35,882	62,499	26,337	170,452
R^2	0.030	0.005	0.003	0.026	0.016

Note: Standard errors are clustered at the institution and first year of employment level.