Changes in Faculty Composition and Stagnating State Support for Higher Education

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Abstract

State support for higher education per-student has stagnated while universities have substituted towards contingent lecturers and away from tenure-track/tenured professors. This analysis relates these changes in the faculty composition at public universities to the fall in state funding per student for higher education, using a shift-share approach to identify changes in a state funding among public universities. A decrease in a university's funding of 10%, via a shock to state higher education funding, decreases the number of assistant professors per student at a public university by 1.4% and full professors by 1.2%, yet increases the number of lecturers per student by 4.4%. Local projection estimates show that these effects linger for up to three years after the initial funding shock. Analysis of all the professors at Illinois public universities 2011-2021 shows that incumbent professors are not affected by the changes in state funding, and suggestive evidence shows that these changes in faculty composition arose by impacting the hiring of new professors at public universities impacted by the funding shocks. These results show the long-term effects of stagnating state support for higher education, and raise questions about the direction that public education heads as these financial headwinds show no sign of dissipating.

Key-words: State and Local Budget and Expenditures, Higher Education, Public Sector Labour Markets

JEL Codes: H72, I23, J45

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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, 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 per student, and this affected their composition of faculty. Falls in public university revenues from the state, instrumented by state-level funding shocks, lead to a fall in the number of tenure-track or tenured professors per student within a university, and an increase in the number of lecturers. 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 wider 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 public university received around \$11,600 per enrolled student in 1990, yet only \$8,300 per enrolled student in 2021. This fall is driven by stagnating funding provided by state governments, while enrolment among public universities rose by 46% over the same time period. At the same time, the number of professors per student at private universities stayed relatively stable at 0.045, yet fell from 0.04 to around 0.35 professors per student at public universities. This change was driven by a fall of over 20% in the count of associate and full professors per student at public universities.

To identify changes in state funding for higher education, I employ a shift-share instrument for state funding of public universities, which exploits reliance on state funding and yearly shocks to the amount an entire state funds higher education (Deming & Walters 2017, Chakrabarti, Gorton & Lovenheim 2020). 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 changing state priorities. 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 support for higher education and how much each university historically has relied on that support.

Negative changes in state funding affects faculty composition at public universities, away from tenured and tenure-track professors towards non-tenure track lecturer positions. A reduction of 10% in state funding, via a shock to state appropriations, leads to a fall in 1.4% in the number of assistant professors per student within a university, 1.2% for full (tenured) professors, and an increase in 4.4% the number of lecturers per student. Local projection estimates show that these effects linger for three to four years after the initial funding shock. Over the same time period, state funding fell by around 35%, while the count of professors per student fell by 9%, so that these results show that falls in state funding explain around a third of the observed shift away from tenure-track and tenure professors towards contingent faculty. Additionally, I use individual level data on professors at Illinois public universities over 2010-2021 to investigate whether the shocks to state funding affected individual professors. Incumbent professors were not meaningfully affected, in terms of total salary, promotion rate, or rate of leaving the Illinois public university system. Yet, the hiring rate of tenure-track professors declined over this time period for all public universities. This shows that changes in faculty composition came about by hiring reductions of new professors at public universities.

Absent this analysis, it is not immediately clear why stagnating state support and changes in public university faculty composition would be causally linked. Over the 21st Century there have been drastic changes to college selectivity, where the top universities have become more selective while the average university less selective (Hoxby 2009). While the average public university is becoming less selective, it is possible that their most productive or research-focused faculty more often move to more selective and prestigious (and often private) institutions, so that over time public universities (on average) substitute towards contingent lecturers. This is one way in which the trends may be concurrent, but not causal. This analysis shows that stagnating in state funding for public universities cause the changes in faculty composition, explaining about 40% of the observed substitution towards contingent lecturers, so that it is possible that other systematic changes in higher education (such as changing selectivity) may explain the rest of the variation.

A number of studies have shown that stagnating state funding for higher education negatively impacts student outcomes. Deming & Walters (2017) show that increases in public university spending (via funding shocks) increases enrolment and degree completion among students,[1] that high school students exposed to similar public school funding shocks are less likely to attend college (Jackson, Wigger & Xiong 2021), and that these shocks induce public universities to rely more on tuition as a source of revenue (Bound, Braga, Khanna & Turner 2019). Chakrabarti et al. (2020) use the same methodology to show that increases in state appropriations lead to degree lower completion time[2] and later-life debt for students.

Faculty are a core component of the US higher education and research-innovation university system, yet their composition within universities, and its relationship with higher education finances has so far not been studied. The closest previous examples study how university endowments react to negative endowment shocks (Brown, Dimmock, Kang & Weisbenner 2014) and the 2008 recession (Turner 2014), and multiple theoretically model university decision-making and faculty hiring (see e.g., Abe, Watanabe et al. 2015, Johnson &

[1] Miller & Park (2022) further analyse the effects of falls in university revenues, by finding that reductions in public universities tuition prices (suggestively motivated by falling state funding) leads to reductions in provided financial aid.

[2] Bound & Turner (2007) use similar variation in state funding per student to show that lower funding leads to lower higher education completion rate at public universities,

Turner 2009, Courant & Turner 2019). Lastly, instruction costs within individual universities vary substantially across subject areas, primarily thanks to department differences in class size and faculty salaries (Hemelt, Stange, Furquim, Simon & Sawyer 2021).

The number of professors, both in absolute terms and relative to number of students, may be particularly important for quality of instruction and thus educational outcomes. Small class sizes in secondary schools lead to increases in test scores (Angrist & Lavy 1999), and UK university students perform worse academically in particularly large classes (Bandiera, Larcinese & Rasul 2010). Regarding faculty composition, the literature is not decided on whether contingent lecturers lead to better or worse education outcomes relative to tenured faculty. Adjunct professors are shown to better undergraduate teachers at highly selective universities (Bettinger & Long 2010, Figlio, Schapiro & Soter 2015), yet universities who use a greater share of lecturers have lower graduation rates (Ehrenberg & Zhang 2005). Notably, students taught by part-time adjuncts lecturers have worse student outcomes than full-time professors at a less-selective university (Zhu 2021), but this difference disappears when individual lecturers gain a full-time teaching position at the university. My approach focuses on count of professors per student at universities, and considers faculty count and composition change as possible mechanisms for how stagnating state support for higher education negatively impacts student outcomes (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 including finances and enrolment, and *Illinois Board of Higher Education* (2021, IBHED) for data on every professor in the Illinois public university 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.[3] Data are consistent between the years 1990 and 2021,[4] and provide information on the total revenues a university received from every source (including state governments), enrolment, plus faculty count and total expenditures on salaries.[5] I restrict analysis to public, four-year, degree-granting institutions, as these institutions adhere to a standardised concept of faculty profile, where tenure and title of appointment (lecturer, assistant professor, etc.) are relatively standardised. 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 enrol at a four-year institution (Mountjoy 2022), so that these institutions are not considered.

IPEDS reports the count of professors employed by position, as well as total salary expenditures by position. 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[6] for professors by position (lecturer, assistant, tenured, total). Table 1 presents summary statistics for relevant variables in these data.

IPEDS provides information at the university level, yet lacks information on the distribution of salaries and professor count within a university.[7] To investigate the distribution,

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

[4]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.

[5]I combine the Urban Institute's 2018 compilation of IPEDS data for the years 1990–2017, and manually combine raw NCES data on 2018-2021 for all relevant variables. Figures for enrolment, faculty counts and salaries come from the raw NCES version of IPEDS for all years, addressing inconsistencies in the Urban Institute's data formulation for these variables.

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

[7]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, 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). Similarly, IPEDS reports of the average salary paid to professors at private institutions also disagree with other sources, so are not considered in this

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

Statistic	Mean	St. Dev.	N
Enrollment, institution reported	11,511	10,821	18,504
State appropriations (millions 2021 USD)	99	125	18,504
Total revenues (millions 2021 USD)	425	793	18,504
Non-instutional revenues (millions 2021 USD)	202	265	18,504
Lecturers count	60	74	17,329
Assistant professors count	113	102	17,826
Full professors count	261	284	17,929
All professors count	429	437	18,504
Lecturers mean salary (2021 USD)	58,212	13,244	16,686
Assistant mean salary (2021 USD)	74,319	13,849	17,750
Full mean salary (2021 USD)	99,675	23,590	17,837
All mean salary (2021 USD)	81,570	25,055	17,759

I integrate individual-level data for every public university professor in the state of Illinois between the years 2010-2021. IBHED hosts 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.[8] This publicly available data provides the basis to build a panel of Illinois public university professors 2010-2021; I define a professor as an individual by their first plus last name and university pairing, and link this database to IPEDS regarding 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.[9]

analysis.

[8]The universities included are all campuses of the nine Illinois public universities: Chicago State University, 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.

[9]Summary statistics for this group, which over-represents lecturers compared to assistant and full professors, can be seen in Table A1. The reasons for considering the sub-sample with identified year of hire in the range

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

1.2 Trends in Finances, Enrolment, and Faculty Composition

The institutional environment for how states appropriate funding allows for wide variation in state funding for higher education, both between states and across years in each state. A state government plans an annual budget a couple of years ahead of the fiscal year, and the legislature chooses to approve or reject a budget request put forth by the governor's office.[10] US state 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. 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 support for higher education, and are subject to fiscal constraints. State appropriations to higher education are a particularly attractive area of state spending to

2011-2021 are explained in subsection 3.3.

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

absorb negative shocks to state finances (Delaney & Doyle 2011).[11] Additionally, there is yearly variation in the number of higher education students in each state (Turner 2014), so that per-student state appropriations vary on multiple dimensions.

Public university revenues on average stagnated across there years 1990–2021. Figure 1 show the trends in revenues for the mean public university for 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. At the same time, total state appropriations stagnated at around \$100 million per year-university for 1990–2008, falling around 2008 and have not recovered ever since. While public universities experienced a stagnation in state support, private universities were not exposed to the same constraints, receiving \$37,000 per student in 1990 and \$49,000 in 2021, experiencing no corresponding decline in any specific component.

At the same time, student enrolment 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 enrolment at private universities has also risen over the same time period, but not as drastic in either relative or absolute terms; the mean private university grew from 9,800 students in 1990 to 11,800 in 2021. This means that revenues per student have stagnated across all measures (seen in Figure 1b), and particularly fallen from a mean of \$11,000 per student in 1990 to less than \$8,000 per student in 2021.

There are large differences in the average number of professors per student between the private and public sector. Figure 3 shows that private universities start with a higher baseline of around 4.5 professors per 100 students, and exhibited yearly variation of less than

[11] Delaney & Doyle (2011) fully describe 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, and Figure 1 observes these same trends.

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

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

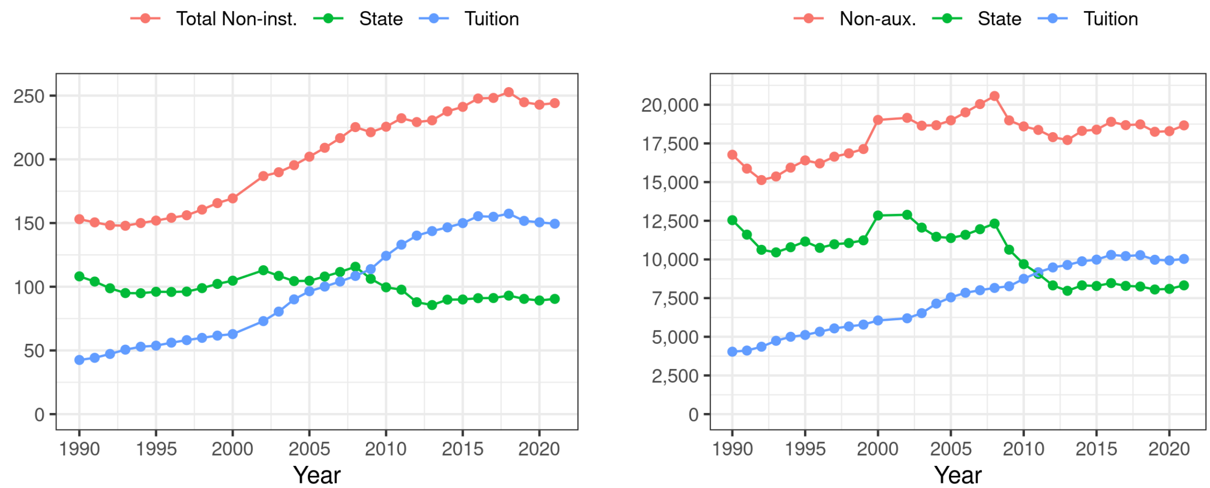
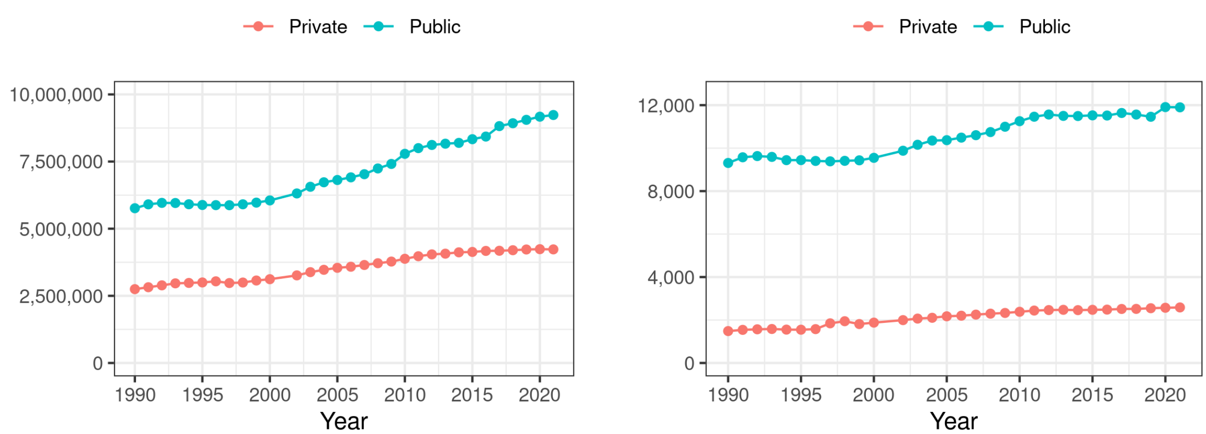


Figure 2: Total Student enrolment, by University Sector, and Year.

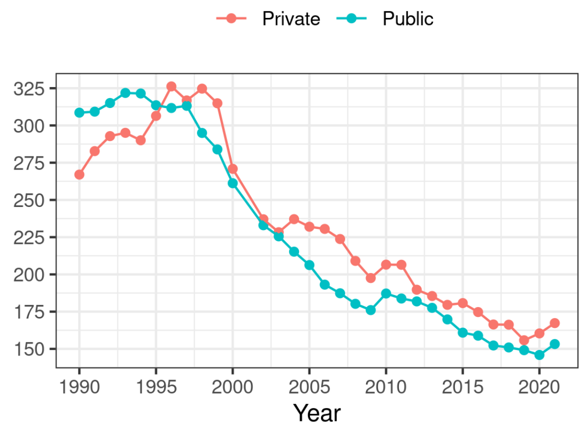
(a) Total. **(b)** Mean, University Level.



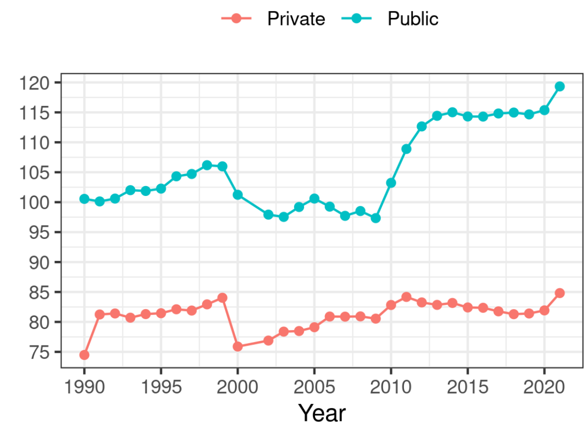
0.5 professor per hundred students over the thirty years. Public universities start with 3.9 professors per hundred students, and this number falls to around 3., with the largest fall in the 2008-2011 time period. We see a similar difference in baseline, and fall for the years

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

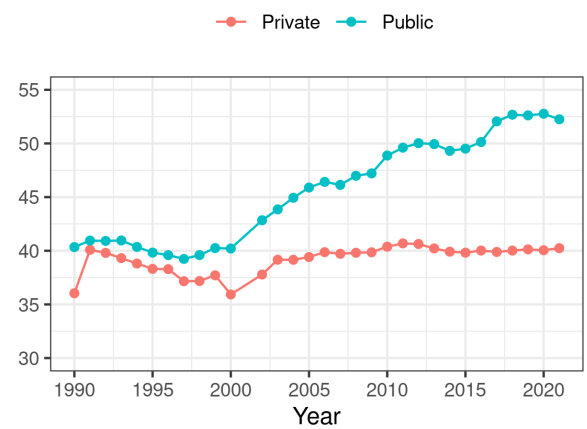
(a) Lecturer



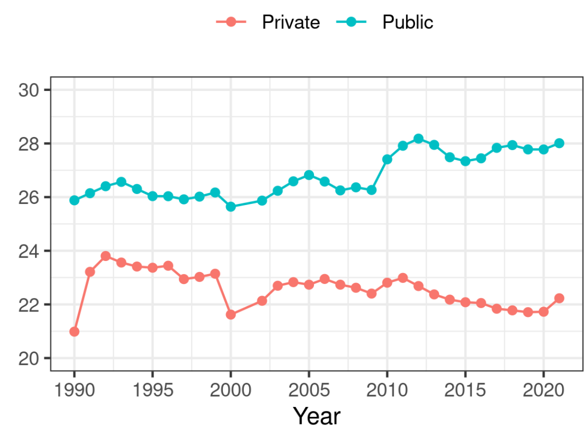
(b) Assistant.



(c) Full.



(d) All.



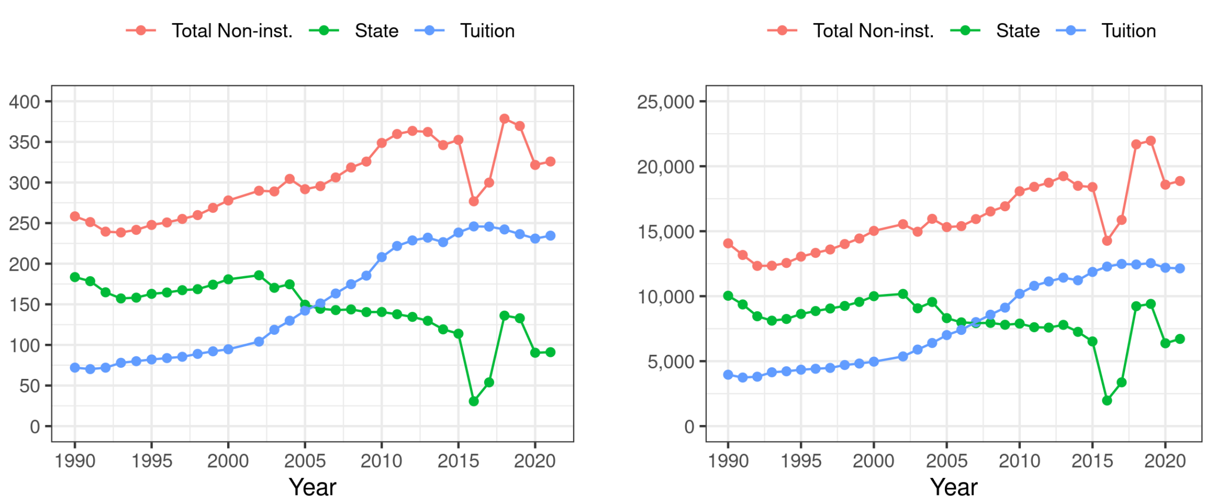
2008-2011 for assistant professors. Private and public universities have similar numbers of associated and full professors before the year 2000, yet this number has fallen by over 20% in the next 20 years only for public universities: in 2021 the mean public university has 6 fewer full professors per hundred students than the mean private university. Over 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 rate that Illinois funds higher education has stagnated to a similar extent as the average for the entire country. Figure 4 shows the trends for revenues among the seven Illinois public university campuses, including the falling share of state appropriations and substitution towards tuition revenue.

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

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



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 techniques to continue operating without any resources provided by the state government.[12] While public universities were able to stay open, there were drastic revenue and spending cuts in response to the budget

[12]Fiscal year 2016 refers to June 205 to June 2016, so is the same as the academic year definition.

impasse, as it continued through fiscal year 2017, and ended with a new budget restoring funding to state institutions for 2018. This variation in public university revenues via the state appropriations channel, stemming entirely from political disagreements — not from state decisions regarding higher education and its finances (Young, Wiley & Searing 2020) — mean that Illinois public universities exhibit sizable changes in their state appropriations over 2010-2021, of similar order to those for the rest of the country over 1990–2021.

2 Conceptual Framework

While state support for public higher education has stagnated at the same time as education costs rose, there are multiple possible ways that a university can respond. Deming & Walters (2017) established that corresponding rises in tuition did not offset the falling state support, so that university spending (per student) fell in response to these persistent, negative state funding shocks. There are multiple ways that these changes in finances may affect the faculty composition at public universities.

Most universities hire a number of new professors every year, either to expand their departments or to replace leaving professors. The number of professors hired in each year is usually highest among non-tenured adjunct faculty, as these instructors are mostly hired on short-term contingent contracts, so that they are less costly to hire (or to not reinstate) in response to yearly changes in teaching needs. Secondly, tenure-track assistant professors are hired to replace leaving assistant professors, and are most often hired with a four to six year contract and agreement for tenure consideration. Lastly, tenured professors have undergone review and have successfully secured a full-time appointment at their university with no expiration date; tenured professors may be hired from outside a university, though this position has the lowest yearly hiring rate among most universities. It is common for universities to restrict their faculty hiring in the face of financial shocks. Since the yearly hiring rate is highest among lecturers and assistant professors, financial shocks may lower the number of lecturer and assistant professors at public universities the most, if faculty hiring is affected by falls in funding.

Additionally, faculty salaries may be affected by changes in public university finances. When the university has a lower budget for its yearly hiring, it may respond by lowering the salary they offer to new hires. This possible effect may not be the same across each position of professor; tenured faculty are often hired away from another university, so that new tenured professor hires may be less likely to accept a lower salary offer from a public university.[13] Yet salary for all the professors, not just new hires, may also be affected: multiple universities passed a university-wide pay-cut for their faculty in response to state budget cuts around the 2008 recession, for example.[14] Faculty are not paid the same by position, so that there are financial consequences for a university promoting their own faculty. In response to tightening fiscal restraints, universities may be less likely to grant tenure to assistant professors (as tenured professors generally receive a salary raise and long term contract), or to promote tenured professors from associate to full professor.

It is not immediately clear which effects will dominate, or whether tenured professors vs lecturers will be affected more by changes in their university's funding. Yet, there is one empirical fact worth noting: a mean assistant or tenured professor earns more than double that of an adjunct lecturer per year (see Table 2), and the tenure contract means universities must pay a higher salary for a guaranteed number years, more so than for contingent lecturers. If a public university's primary obligation is to teach, and they must fulfil this objective with fewer and fewer resources, then they may substitute away from tenure-track and tenured professor towards contingent lecturers to achieve this obligation.[15]

[13] Faculty often consider their outside options, as in offers for employment and/or promotion from other universities. See Blackaby, Booth & Frank (2005) for an overview of faculty outside options.

[14] Indeed, Cornell University implemented hiring freezes and a nominal salary reduction for professors, in anticipation of a financial shock in early 2021. The salary cut was not permanent, as the oncoming financial shock turned out to not be as serious as projected, so that the cut was returned to professors in the year 2021.

[15] That is, substituted away from tenure-track and tenured professors according to the salary ratio, and

3 Empirical Framework

Universities employ professors, so it stands to reason that if a university experiences a fall in one of their revenue sources (similar to a demand shock in the private sector) that they may respond by making adjustments with respect to their labour force of professors.

Naïvely we can analyse the relationship between professor-outcomes $Y_{i,t}$ at university i in year t as a result of state funding per student $X_{i,t}$. This analysis focuses on the outcome of professor count per student within each university-year. So that β represents the association with these outcomes and state funding per student,[16] 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 with respect to state funding per student.

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

Yet a university's finances are not exogenous to state decisions for support of higher education, or exogenous to internal institutional decisions. Instead, the state government and university administration undertake a complex process of allotting resources across multiple different priorities, including instruction, research, or between departments. Importantly for this analysis, revenues received from an institution's state government provide opportunity to address this endogeneity.

3.1 State Funding Shocks

This analysis uses a shift-share instrument to address endogeneity concerns for the amount of funding a state gives to each of its public universities. Deming & Walters (2017), Chakrabarti

the relative productivity between these two positions.

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

et al. (2020) develop the instrument for public university finances by exploiting a shift-share instrument for changes in state-level funding interacted with university reliance on state funding in a base period.

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

The system exploits the fact that institutions who rely on state funding more will be affected by state appropriation shocks. $Z_{i,t}$ is the instrument for (log) state appropriations for institution i in year t, interacting the average funding for universities in state $s(i)$ with reliance on state funding relative to total revenues, averaged across the base years 1990–1993.[17] $Z_{i,t}$ is constructed as negative to reflect the fact that the long term trend in, and most of the short-run shocks to, state funding for higher education has been negative. State funding has been falling, so that the instrument describes shocks to university revenues, mostly in a negative direction.[18] The instrument approach relies on the conditional independence assumption, that the instrument is independently assigned to the universities. While this assumption is fundamentally untestable, we see that univeresities are by-in-large smaller (in terms of enrolment, total revenues, and professor count) at the top of the state funding shock distribution. Though on a per student basis, there is little difference across the distribution (except in the outcomes under consideration). Yearly and individual fixed effects are included in regressions throughout to implicitly condition on mean differences between universities, and strengthen the claim of conditional independence of the instrument.

[17] 1990–1993 are defined as data for public university 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.

[18] Chakrabarti et al. (2020) note the tendency for public universities to respond to state funding cuts by increasing reliance on tuition, where Deming & Walters (2017) specifically instruments for tuition revenues with collected information on legislative tuition price controls. It may be argued that tuition revenues are confounder between the causal effect of changes in state funding on a university's total revenues, so that this analysis focuses on state support for higher education (not total revenue), as do Chakrabarti et al. (2020). On the other hand, rises in tuition revenues (per student) may arise as result of tuition hikes thanks declining state support, which would mean controlling for tuition would constitute a bad control. Nonetheless, estimates including tuition revenues (per student) as a control in the second stage of the IV estimates produces results of very similar magnitude and direction, and so are omitted.

Table 3: Mean Characteristics for Public Universities, by State Funding Shock Instrument.

Instrument Quantile:	1st	2nd	3rd	4th	5th
State Funding Shock, USD per student	1,423	2,576	3,546	4,995	8,250
State Funding, per student	12,135	9,824	9,102	9,287	13,335
Total Full-time Enrolment	13,555	12,103	11,076	11,239	9,701
State Funding, USD millions	103	95	95	103	101
Total Revenues, USD millions	962	465	345	292	233
Total Revenues, USD per student	113,099	43,997	30,704	25,264	28,170
Lecturer Count	84	66	61	53	38
Assistant Professor Count	147	117	108	107	91
Full Professor Count	346	266	244	245	236
Total Professor Count	567	442	406	402	365
Lecturers, per student	0.008	0.006	0.006	0.005	0.006
Assistant Professors, per student	0.015	0.012	0.011	0.011	0.012
Full Professors, per student	0.027	0.022	0.021	0.022	0.027
Total Professors, per student	0.049	0.039	0.038	0.038	0.046

Note: The column labelled "1st" refers to the mean for all university-year observations in the first quintile (bottom 20%) of the funding shock (per student) distribution, and so on.

The state funding shock is an instrument for the amount of state funding for each university in each year. The first-stage is then as follows, including institution and year fixed effects, where $X_{i,t}$ represents the amount of state funding divided by the number of full-time students attending the university.

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

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 public universities are uncorrelated with unobserved institutional changes of any specific college or university in the state (Borusyak, Hull & Jaravel 2022). 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, 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.[19] Lastly, the shift-share approach assumes that state funding shocks affect faculty outcomes only via affecting university finances.

Table 4: First Stage Estimates, for State Funding by Appropriation Shock.

	Dependent Variable: State Funding			
	(1)	(2)	(3)	(4)
Appropriations Shock	−0.980	−0.350	−0.990	−0.608
	(0.078)	(0.084)	(0.075)	(0.059)
Tuition Revenue			0.063	0.558
			(0.055)	(0.059)
Constant		6.011		−0.982
		(0.688)		(0.751)
Uni. + Year fixed effects?	Yes	No	Yes	No
F stat.	175.636	104.65	156.791	17.487
Observations	18,504	18,504	18,504	18,504
R^2	0.801	0.064	0.801	0.222

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

The shift-share instrument performs excellently as an instrument for universities' yearly state funding. Table 4 presents results of the first-stage regression, separately with and without a control for tuition revenue per student, plus institution and year fixed effects.[20] We note columns (1) and (2) estimate that a shock to appropriations (per student in the entire state) of 10% is associated with 9.8% change in state funding 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) include the tuition revenue control (explained in footnote 18) to exhibit estimates with the inclusion of this possible collider or bad control. Column (3) shows similar estimates to columns (1), (2) thanks to inclusion of fixed effects,

[19]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.

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

so that the fixed effects was effective in soaking variation in per-student tuition revenues at the institution-year level. Column (1) represents the estimates for Equation (3) with fixed effects, omitting the tuition revenue control, and is the preferred form that I proceed with. Lastly, the state funding shock affects university revenues for multiple years after the initial shock (seee Figure A1). We see a decaying, yet real and positive, effect of the shock on revenues for the next 10 years, illustrating that the state appropriation shock is a strong, if fading, instrument for state funding per student and justifying its use in later local projections models.

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

3.2 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 state funding at the university-level — i.e., parameter β in the following.[21]

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

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

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 2005, Basso, Miller & Schaller 2022) to investigate whether the effects of revenues on faculty

[21] It is important to note the treatment effect isolated here; the instrumental variables approach identifies the local average treatment effects, one specific to the instrument. So we interpret this treatment effect as a university's response in employment count and average salaries to state funding changes, changes specific to state appropriation shocks, among the complier group — i.e., universities who respond to funding shocks who would not have made faculty-outcome changes absent the funding shock. Also, we assume that no universities' total revenues increase in response to negative state funding shock (monotonicity).

composition linger for multiple years after the original appropriation shock.[22] Regarding outcomes, I focus on the composition of the professors employed at the university by analysing (log) count per student of, and average salaries paid to, professors employed by the university.

3.3 Instrumental Variables Model, Individual Professor-Level

This analysis additionally uses data on 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, leveraging variation in university finances for the years after 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 professor first joins their institution.[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 affected by changes in university revenues after they have joined the university.[25]

[22]The local projections method is an empirical method to estimate dynamic treatment effects when the treatment of interest is not binary, so that time-series confounding (i.e., treatment in time t is correlated with treatment in time $t-1$) is present even for instrumental variable models. Inference for this model is similar to that for an event study design, so I present estimates in graphical form following that example (Figure 5).

[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 3.2 and Deming & Walters (2017), where the unit of analysis is the university-year, where base year 1990 is more appropriate.

[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 full 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 (e.g., Table A6, A8).

[25]Notice that subsection 3.2 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 projects the effect on the individual.

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 3.1.[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 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 in the same way as that for the university-level outcomes (Table 4), with very similar estimates for the association between appropriation shocks and state funding.

The instrumental variables model is then defined as follows, where $i(j)$ refers to the institution that professor j is employed at, and $Y_{j,t}$ to individual-level outcomes total salary, rate of promotion, and propensity to leave the Illinois public university system. The system includes fixed effects for the institution and first year of employment.[28]

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

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

We then interpret parameter β as the effect of changes in state funding at an Illinois public university, via state appropriation shocks, on an individual professor's outcome $Y_{j,t}$.

[26] The base-share instrument is appropriate for some outcomes with the individual Illinois professors, where appropriate (Table A6, A8).

[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 with and without including fixed effects, and so are omitted.

[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.

4 Results

4.1 University-Level

Changes in state funding have clear effects on the composition of faculty public universities employ. Table 5 presents OLS and IV estimates, where the outcome is (log) count of professors employed at the university, separated by position, and for all professors (Columns 7, 8). For all professors 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 count per student of 0.83%, yet negatively correlated with lecturer count of -1.3%. Lecturers per student is not shown to be correlated with total university revenues. The 2SLS columns show results after identifying state funding with the appropriation shock. All professor count per student increases by 0.53% in response to a 10% rise in total revenues. 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 1.4%, and full professor 1.2%. The count of lecturers per student decreases by 4.4% in response to a (positive) 10% shock in university revenues.

Table 5: 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.

Faculty composition is not only impacted in the same years as a state funding shock, but also for a number years following. Figure 5d shows local projection estimates, where the effect on total professor count per student persists at a magnitude of around 0.1 four years after the initial funding shock. These findings are in line with the observation that universities froze hiring for a couple of yearsin response to 2008 negative budget shocks, particularly for tenure-track positions (Turner 2014), and similarly from shocks to university endowments (Brown et al. 2014). For lecturers we see a negative effect, which lines up with two trends noted in subsection 1.2: public universities revenues (per student) are decreasing at the same time as employment of contingent lecturers increased rapidly. 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), strengthening the case that the two trends are causally linked.[29]

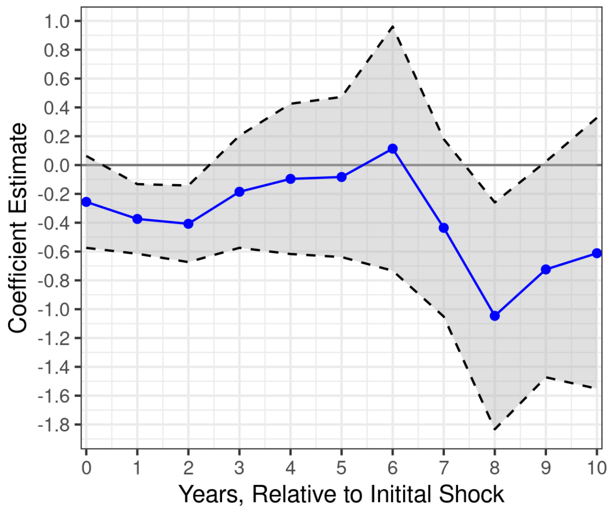
Decreases in university revenues (via state funding shocks) affect faculty composition for at most 4 years after the initial revenue shock. A 10% decrease in state funding increases count of lecturers per student by 4% for the first two years after the initial shock. While count of assistant professors decreases 10 to 18.5% three years later; count of tenured professors decreases 9 to 6% three years later. Together, the total count of professors per student decreases around 1% for three years after the initial funding shock, and the effect is not distinguishable from zero four years after. Figure 5 represents these estimates, using the local projection method, as a series of impulse responses for each outcome of professor count.

These findings show that public universities increase (decrease) their count of tenure-track and tenured professors per student in years when revenues are more (less) plentiful, possibly by increasing hiring intensity or efforts to maintain incumbent professors. In the same vein, when revenues are (not) bountiful, count of tenure-track and tenured professors per student increases (decreases). The mechanism that explains the changes in faculty composition are,

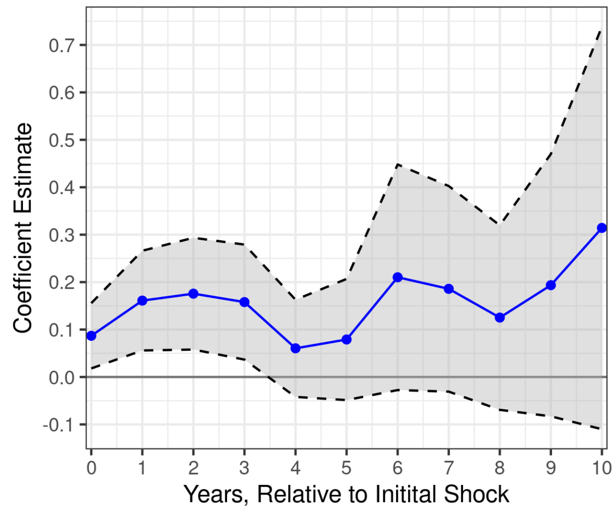
[29]Between years 1990-1999 IPEDS provided count of professors by whether they had tenure (opposed to named position as in Table 5), and Table A3 presents results of the respective regressions by tenure status. Results are relatively similar, yet imprecise from the much smaller number of observations.

Figure 5: Local Projection Estimates for Professor Count per Student, by Professor Group.

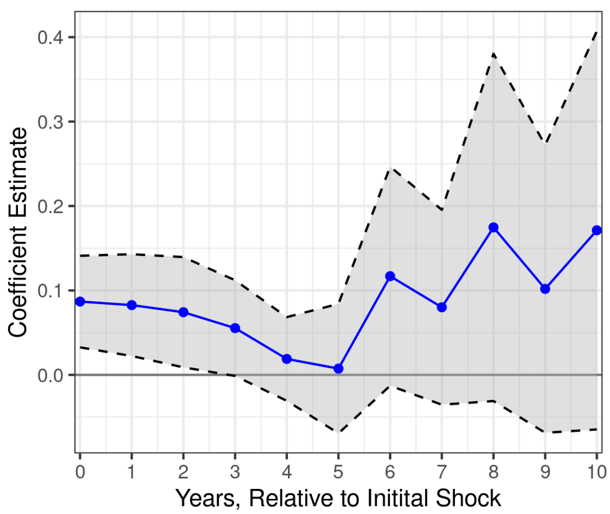
(a) Lecturers.



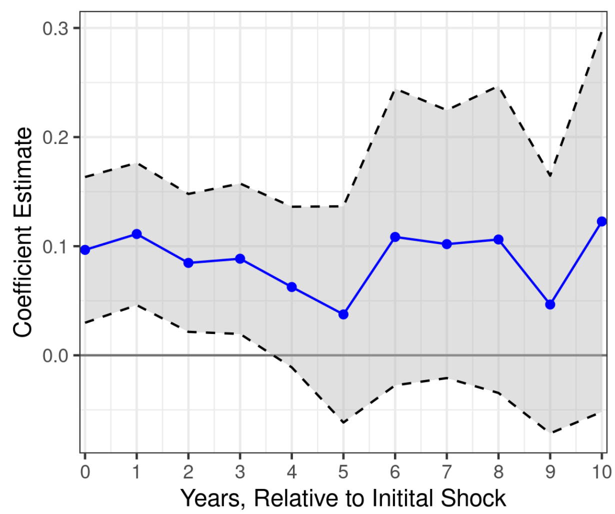
(b) Assistant Professors.



(c) Full Professors.



(d) All Professors.



however, not clear at this unit of analysis; individual data are needed to delve deeper.

4.2 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 6 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 related to revenues, via a shock to appropriations in their first-year of employment. Yet, the starting salary of lecturers is 3.8% higher given an increase in their hiring university's state funding of 10%.

Table 6: 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.

Regarding total salary for every year of employment, Table 7 presents estimates for the elasticity of total salary with respect to university revenues, for the entire sample of professors hired after 2010.[30] The elasticity is non-distinguishable from zero among any position, implying that long-term salaries are not related to state funding. Table A6 presents the same model, for the sample of all professors and using the instrument based in years 1990-1993, similarly finding no relationship.

Note that professor position (assistant, associate, full) is also an outcome, thanks to the

[30] 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.

Table 7: 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.

promotion channel: a university may be less able to promote their professors to higher paying positions when their revenues are constrained. Table A7 shows estimates where the outcome is rate of promotion within each professor position. The lecturer position 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.[31] Furthermore, local projection estimates (Figure A4) show that the there is no promotion effect, among all professors, for any of the following years either. Lastly, Table A9, A10 describes estimates for rate of exit from the employing university among Illinois professors, and finds no relationship with university revenues.

5 Discussion

The results show that the recent stagnation in state funding for higher education has affected the composition of faculty within public universities, away from tenure-track and tenured

[31] Table A8 shows estimates using the base-year instrument among the entire sample, finding the same results.

professors towards contingent 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.

Between academic years the number of professors at a university changes: professors leave an institution (retiring, hired elsewhere, etc.) and other join (they are newly hired, end a sabbatical, etc.). subsection 4.2 shows that most of these channels are unaffected, implying that falls in hiring for tenured-track and tenured faculty must explain most of the substitution towards lecturers away from tenured faculty. Notably, faculty hiring is already know to be heavily impacted by budget shocks. 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[32] did not receive the allocated state appropriations from the state of Illinois on time, so enacted cost-cutting measures to stay fiscally solvent. In response, the university system placed a hold on all hiring for filling state-funded positions and promotions.

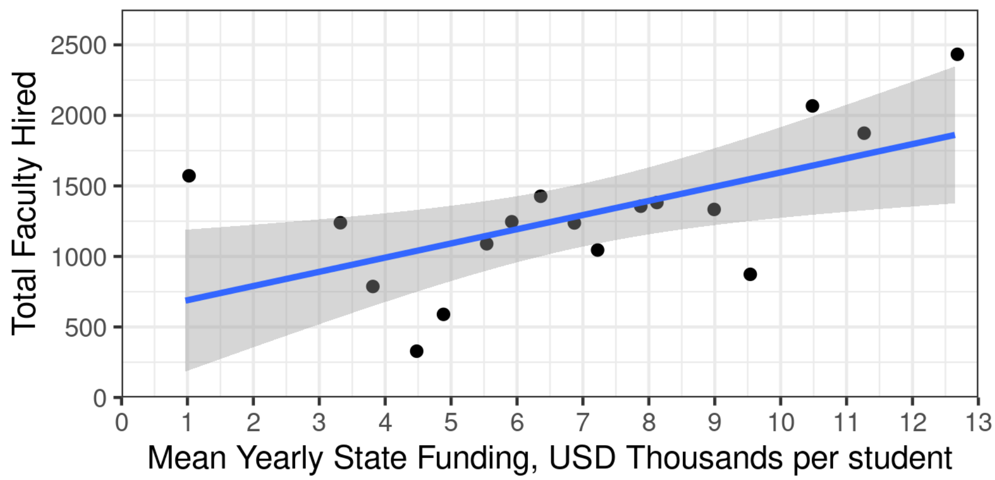
The data used so far measure faculty count, so cannot disentangle which of these channels is most affected by changes in state funding at a public university, yet Wapman, Zhang, Clauset & Larremore (2022) provide a measure of the aggregated total faculty hires at universities over the time period 2011–2021.[33]

Universities with more state funding (for the entire decade) hired more professors (Figure 6). Similarly, the funding shock instrument identifies that an increase in 10% state

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

[33] (Wapman et al. 2022) made an aggregated version of their data open-source, making this sub-analysis possible.

Figure 6: State Funding and Faculty Hired at Public Universities, Total for 2011–2021.



funding at an individual university leads to 13 more faculty hires on average across the decade 2011–2021 (see Table A5).[34] It is clear that public universities' hiring is negatively impacted by falls in state funding, even using highly aggregated data for a total count of hiring across an entire decade. While this analysis strengthens the case negative effects on hiring plays, it is crude for measuring exact magnitudes for the effect on faculty hiring; I leave it to further research to delve deeper into the magnitudes that hiring plays as the primary causal mediator for the effects of falls in state funding on faculty composition at public universities.

6 Summary and Concluding Remarks

This analysis investigates how the recent stagnation in state support for higher education has affected public universities, and their faculty composition. This work contributes to the literature along two primary dimensions. Firstly, by isolating changes in state funding on

[34] These results were produced by integrating the total count of faculty hires for 2010–2021 for the top-ranked 180 US universities with a sum of the funding variables, and then estimating the models specified in subsection 3.2. There were no observable differences in the hiring rate of ale vs female faculty. See subsection A.4 for further details.

public universities via state funding shocks, the analysis provides a plausible mechanism for the observed negative effects on students outcomes that this stagnation has brought (Deming & Walters 2017, Chakrabarti et al. 2020). Secondly, this analysis considers individual professors as the unit of analysis using a dataset (IBHED) new in the economic literature. These data allow for detailed analysis of thousand's of professors' salaries, and are a starting point for further analysis of the determinants of professors wages in the Illinois public university system.

Findings show that public universities have substituted away from tenure-track and tenured professors, towards non-tenured lecturers, in the face of persistent declines in state funding for higher education. The effects on incumbent professors in the state of Illinois are non-distinguishable from zero, which implies that the effect is driven by changes in university hiring of new professors. Each year, public universities are using more contingent lecturers to teach their education students, while private universities continue to employ more tenure-track and tenured professors than their public counterparts. Private universities have always had more tenured professor per student than public institutions, but each year the gap widens.

While costs education have been rising in the US, thanks to multiple overlapping trends (Ehrenberg 2012), public universities have also dealt 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 to the composition of faculty, or to their goals of research and education. These results show large changes in faculty composition, and that stagnation in state support explains at least a third of the observed shift away from tenured professors and towards contingent lecturers. At the same time, private universities were not exposed to financial headwinds of the same magnitude or persistence. If public universities' hiring of faculty is disrupted by a fall in state funding, 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 education students in the US, we should worry about the effects that restricting their funding has on the composition of faculty, and the impact on higher education as a whole.

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A Appendix

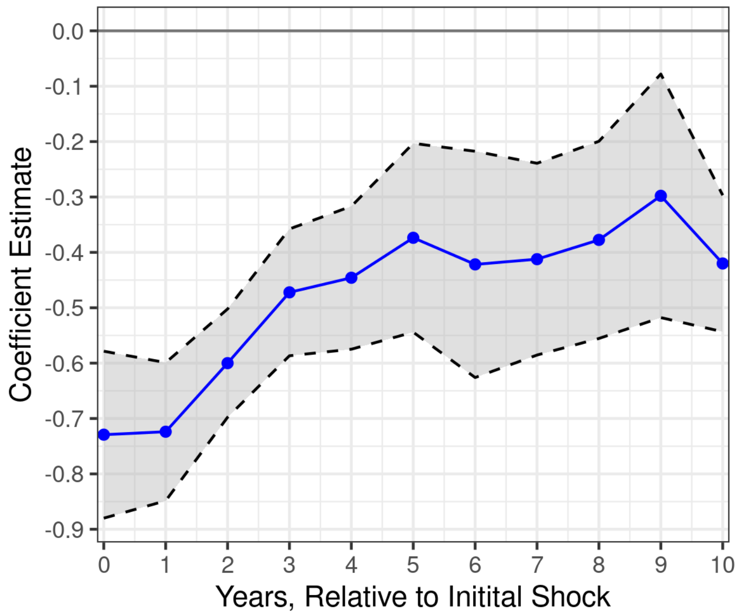
This project used data which are fully public, and computational tools which are fully open-source. As such, all code and data involved in this project are available at this project's Github repository, available at `https://github.com/shoganhennessy/state-faculty-composition`. They may be used for replication, or as the basis for further work, as needed. Any comments or suggestions may be sent to me at `seh325@cornell.edu`, or raised as an issue on the Github project.

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 3.
- *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 Local Projection Estimates

Figure A1: Local Projection Estimates for First-Stage Equation (3).



A.2 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

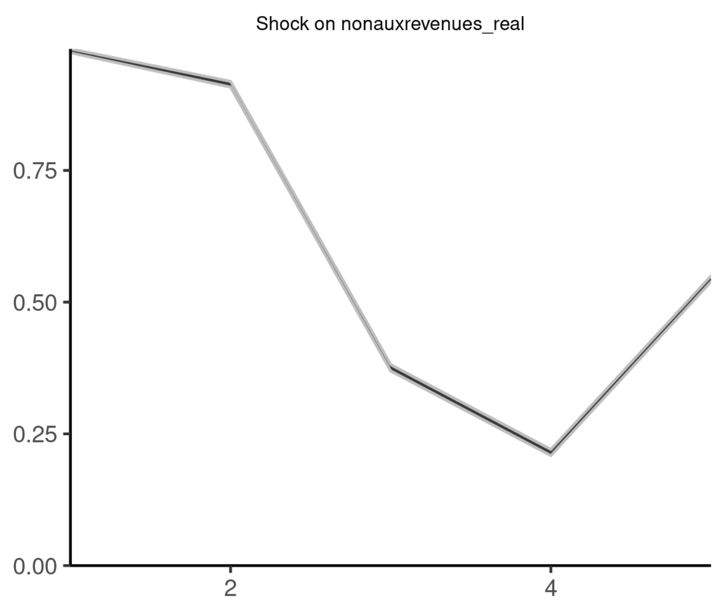
Note: This table presents the summary statistics for professors with an observed year of first-year at their university.

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.	1508.997	33.586	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 A2: Local Projection Estimates for First-Stage Equation (7).



A.3 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 position. Similarly, Figure A3 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

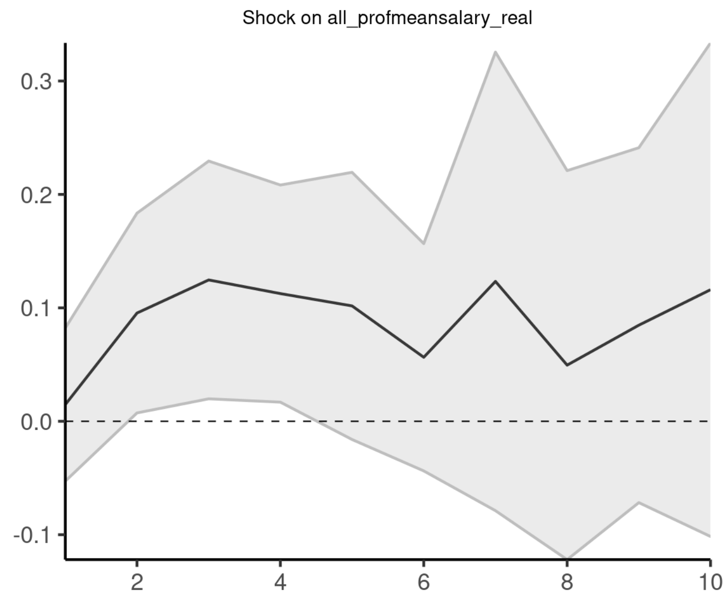
Note: Standard errors are clustered at the university-year level.

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 A3: Local Projection Estimates for Professor Salary, Mean within Each University.



A.4 Additional Results, Faculty Hiring

These results were collects by using the open-source network data by Wapman et al. (2022), summing the count of hires a university made for 2011–2021 across the network structure of the data, and integrating a sum of all revenue related measures from IPEDS data.

Table A5: OLS and 2SLS Estimates for University Faculty Hiring, Total for 2011–2020.

	Dependent Variable: Hiring Count					
	Men		Women		Total	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
State Funding	0.810	1.307	0.851	1.324	0.854	1.306
	(0.223)	(0.365)	(0.236)	(0.335)	(0.221)	(0.351)
Observations	157	157	157	157	157	157
R^2	0.397	0.367	0.416	0.385	0.409	0.382

Note: Standard errors are clustered at the state level.

Note that yearly variation is not observed here, so that only the aggregate level, for 180 universities, can be considered.

A.5 Additional Results, Individual-Professor Level

Table A6: 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 A7: 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 A8: 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 A4: Local Projection Estimates for Promotion Rate at Illinois Universities.

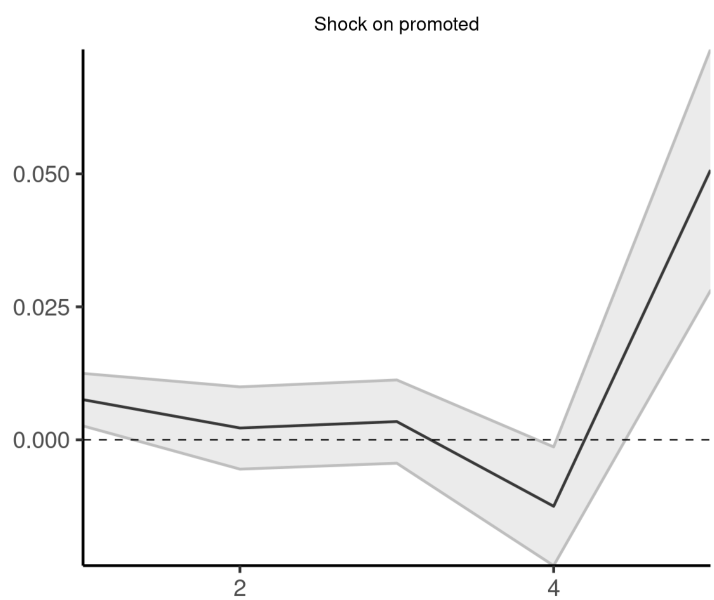


Table A9: 2SLS Estimates for Faculty Exit Rate at Illinois Universities, using Rolling Instrument.

	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 A10: 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.