The Impact of State Budget Cuts on U.S. Postsecondary Attainment

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Abstract

Increasing postsecondary attainment rates is an important economic priority, yet little is known about whether public subsidies can increase college attendance and completion. This paper studies the impact of state budget cuts to higher education on all U.S. public postsecondary institutions between 1990 and 2013. Using a budget shock measure driven by historical reliance on state appropriations, we find large impacts of budget cuts on enrollment and degree completion. We find no evidence that enrollment declines are due to budget cuts being passed through as higher prices - rather, all of the impact is explained by spending cuts.

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1 Introduction

Postsecondary attainment is strongly related to economic growth (Hanushek and Woessmann, 2008; Gennaioli et al., 2013; Hanushek et al., forthcoming). Yet the share of college-educated youth in the U.S. has grown slowly in recent years, compared to more rapid growth in other developed nations (OECD, 2013; Autor, 2014). Thus increasing U.S. degree attainment is an important national economic priority.

While there is a strong positive correlation between per student spending and rates of degree completion in U.S. public postsecondary institutions, there exists little causal evidence of the impact of changes in per-student spending on degree completion (e.g. Bound and Turner, 2007; Deming, 2017). One view is that higher spending pays for administrative bloat and consumption amenities, in which case lower levels of spending may be cost-effective (see, e.g., Ginsberg, 2011; Ehrenberg, 2012; Jacob et al., 2013). On the other hand, spending cuts may reduce degree completion by harming the quality of instruction, limiting the number and variety of course offerings, increasing class size, or moving students into non-credit-bearing remedial courses (Bettinger and Long, 2009).

This paper studies the effects of state funding cuts on attainment and degree completion at U.S. public postsecondary institutions. Our main data source is the Integrated Postsecondary Education Data System (IPEDS), a panel of U.S. postsecondary institutions with continuous coverage between 1990 and 2013. The panel design of IPEDS allows us to study the impact of budget cuts on individual institutions in an event study framework. Our empirical strategy addresses key issues such as serial correlation in outcomes and reverse causality (enrollment declines causing budget cuts, rather than the other way around). However, we first show that the impact of higher education budget cuts is visible in aggregate data.

Figure 1 presents a simple event study that compares the timing of particularly large state budget cuts - 15 percent or more - to the average percent change in state-year enrollment (left-hand panel) and bachelor's degrees awarded (right-hand panel).[1] Enrollment growth averages 2 percent per year in the three years prior to a budget cut, but drops to less than 1 percent in the year of the budget cut and becomes negative two years later. We find a similar pattern for bachelor's degrees, with 2 to 3 percent yearly growth prior to a budget cut but a sharp slowdown in the years afterward.[2]

While Figure 1 provides suggestive evidence of a link between budget cuts and postsecondary attainment, the timing of budget cuts is not random. State appropriations for higher education fluctuate with the

[1] Over the 1990 to 2013 period, 30 states cut their higher education budget by 15 percent or more in a single year. We express the outcomes as yearly percent changes in order to account for differences across states in size, and for differences in the timing of budget cuts (since enrollment is growing overall during this period). For budget cuts, year zero is the summer before the Fall-to-Spring academic year in which enrollment and degrees are measured. Appendix Figure 1 presents a similar set of results but in enrollment levels, with the sample restricted to a balanced panel of states where we observe enrollment 5 years before and after the budget cut. Those figures show a clear leveling off from an otherwise upward trend in the 3-4 years after a budget cut, for both enrollment and degrees awarded. We also find similar results with slightly different definitions of enrollment (such as using full-time equivalent enrollment, or restricting to full-time undergraduates). Finally, our results are robust to choosing other thresholds for a "large" budget cut, such as 10 percent or 20 percent.

[2] Notably, while the impact on bachelor's degrees is delayed relative to enrollment, it also begins before any newly enrolled students would have had time to complete their studies. This timing is consistent with our main results, and suggests that the decline in degrees awarded is due to lower persistence among already-enrolled students rather than fewer new students matriculating. See Section 4 for more details.

business cycle. While policy decisions about higher education funding generally operate at the state level, uniform state-level budget cuts have greater proportional impacts on institutions that rely more heavily on appropriations as a source of revenue (Kane et al., 2003; Barr and Turner, 2013).

In this spirit, we construct a state budget shock measure that interacts total yearly state appropriations for higher education with each institution's historical appropriations revenue share. This approach purges variation in funding driven by policymakers' decisions about which institutions to support in particular years, and allows us to control for permanent differences across institutions, changes in common outcomes within a state, and important time-varying determinants of the demand for higher education such as state and local unemployment rates. We also show that the budget shock variable effectively controls for differential pre-trends in enrollment and other outcomes. Interacting cross-sectional variation in exposure to a policy treatment of interest with aggregate changes is common in studies of local labor markets, immigration, and the opening of trade with China (Bartik, 1991; Blanchard and Katz, 1992; Card, 2001; Autor et al., 2013).

We find large impacts of state budget cuts on postsecondary enrollment. Our estimates imply that a movement from the 25th to the 75th percentile of our measure of state support in a given year generates a 3 percent increase in enrollment. We also find positive and statistically significant causal impacts on degree completion, including bachelor's degrees. These impacts are driven mostly by increased persistence and degree completion among already-enrolled students, rather than increases in initial college matriculation.

Schools respond to budget cuts both by reducing spending and raising tuition, and our approach measures the net impact of adjustment along both margins. Understanding the policy implications of our findings requires distinguishing between these two causal channels. To this end, we utilize a newly assembled data source of tuition caps and freezes to identify institutions that are constrained in their ability to adjust prices. Using the budget shock and price cap instruments together in a two-stage least squares (2SLS) framework, we estimate a large, positive, and statistically significant elasticity of enrollment with respect to spending, but a modest and statistically insignificant tuition elasticity. Moreover, we find that academic support spending - including tutoring, advising and mentoring - is particularly responsive to state budget shocks. This is consistent with recent studies finding large impacts of student supports on persistence and degree completion (Angrist et al., 2009; Bettinger and Baker, 2011; Barrow et al., 2014). While ultimately the mechanisms are only suggestive, our results are most consistent with spending improving quality by lifting informal capacity constraints such as course waitlists and inadequate advising (e.g. Bound et al., 2012).[3]

To our knowledge, this is the first paper to directly demonstrate a causal link between state higher education funding and degree attainment in U.S. postsecondary institutions. The most closely related paper is Bound and Turner (2007), who show that larger state cohorts have lower degree attainment rates. While they argue that lower public subsidies per student are the key causal mechanism, they do not directly

[3]In principle, spending cuts could lead to formal capacity constraints through admissions quotas. We think this is unlikely to explain our results, for two reasons. First, most of the colleges in our sample (and nearly all of the community colleges) accept every student who applies and meets minimum academic qualifications. Second, a web search revealed the existence of formal capacity constraints in only a handful of states and years. Our results are robust to excluding schools that accept fewer than 50 or 75 percent of applicants, and they are nearly unchanged when we exclude states and years with formal capacity constraints from the analysis.

measure changes in public spending on higher education, nor do they use institution-level data on student outcomes. Our results complement studies of "cohort crowding" and college quality, which draw linkages between changes in college resources, declining completion rates and increased time to degree over the last twenty years (Turner, 2004; Bound and Turner, 2007; Bound et al., 2010, 2012). Our findings are also consistent with recent evidence indicating that increased resources boost educational attainment and other outcomes at primary and secondary schools (Card and Krueger, 1992; Jackson et al., 2016; Lafortune et al., 2016). Finally, we find that budget cuts have large impacts on attainment at many mid-tier public institutions, which Chetty et al. (2017) show are important mediators of intergenerational mobility.

2 Data and Background

2.1 Data Description

IPEDS is a survey of colleges, universities and vocational institutions conducted annually by the U.S. Department of Education (DOE). The Higher Education Act requires postsecondary institutions to participate in IPEDS to retain eligibility to administer Federal Title IV student aid (Pell Grants and Stafford Loans). IPEDS collects information on student enrollment overall and by race, gender, age and student status, as well as degree completion by level and field of study. IPEDS also collects detailed information on institutional finances, including revenues and expenditures by source. Financial data are collected as of the fiscal year, which usually begins in July. Enrollment data are counted for the fall-to-spring academic year.

IPEDS collects data at the campus level using a unique longitudinal identifier. Campus-level data allows us to separate enrollment and finances for branch campuses of university systems. We supplement the IPEDS data with state legislative appropriations data from Grapevine, an annual survey compilation of data on state support for higher education administered by the State Higher Education Executive Officers (SHEEO) Association and the Center for the Study of Education Policy at Illinois State University.[4] We also match the IPEDS to publicly available data on state and county unemployment rates collected by the Bureau of Labor Statistics, as well as annual data on state tax receipts and other forms of state government spending such as Medicaid. Finally, we match IPEDS to state- and county-level data from the Census and the American Community Survey (ACS).

Appendix Table 1 presents descriptive statistics for the colleges in our sample. Most public institutions derive almost all of their revenue from state appropriations, tuition and fees, and Federal financial aid. The baseline revenue share in state appropriations is generally higher for less selective institutions but it varies widely, with a mean of 44 percent and an interquartile range of 21 percentage points.

[4]The Grapevine data can be found at https://education.illinoisstate.edu/grapevine/historical/. We measure appropriations from Grapevine rather than IPEDS because of concerns about duplicate reporting of state funding across campus branches of institutions, as well as errors in administrator survey responses. IPEDS appropriations aggregated to the state-year level are similar to corresponding measures in Grapevine (correlation = 0.83).

2.2 Higher Education Appropriations and Tuition

Our description of higher education funding relies on a SHEEO survey of state budgetary processes (Parmley et al., 2009). While the details differ across states, a typical budgetary process unfolds as follows:

1. One to two years in advance of the fiscal year, a state higher education coordinating board develops a budget request that covers all public institutions in the state.

2. The governor proposes a budget to the legislature, and they negotiate over the course of several months.

3. The budget is typically ratified in the spring and takes effect the following fall. A key source of uncertainty in this process is the possibility that budget requests will not be fully funded, and this is especially likely when tax revenues are less than expected.[5]

Importantly, states are mostly unable to smooth business cycle fluctuations in tax revenue. Nearly all states have some sort of balanced budget requirement, and higher education spending often serves as the "balance wheel" used to meet these requirements when tax revenues fall short of projections (Kane et al., 2003; Delaney and Doyle, 2011).

States differ markedly in their support for higher education - see Appendix Figure A1 for trends in per capita approprations across four large states. There is wide variation in spending, even across nearby states with similar demographics. However, the overall trend is toward declining support - between 2000 and 2014, inflation-adjusted state appropriations per full-time equivalent student fell by 28 percent, and total per-student spending fell by 16 percent (Baum and Ma, 2014).

3 Effects of State Support for Higher Education

3.1 State Funding and Institution Outcomes

Figure 1 suggests that cuts in state appropriations for higher education are associated with declines in enrollment and degree completion. To describe the relationship between state funding and institution outcomes more systematically, we estimate regressions of the form:

$$Y_{i,t} = \gamma_i + \psi_t + \sum_{\ell=-L}^{L} \delta_\ell X_{i,t-\ell} + u_{i,t}, \tag{1}$$

where $Y_{i,t}$ represents an outcome of interest for institution i in year t, γ_i and ψ_t are institution and year fixed effects, and $X_{i,t}$ is log state appropriations. In each case, the timing of financial variables is July of year t, whereas enrollment and degree outcomes are measured for the following academic year, e.g. Fall of year t through Spring of year $t+1$. The coefficient δ_ℓ describes the relationship between appropriations in year

[5]The SHEEO survey received responses from 43 states. Institutions submit budget requests individually in only six states. Governors vetoed or reduced specific budget line items in only 14 states. The executive branch fully funded the initial budget request in about half of cases, and that number is slightly lower for the final budget.

t and outcomes ℓ years earlier, controlling for permanent differences across institutions, changes over time common to all institutions, and tuition or spending in other years. The model includes 4 leads and 5 lags (for ten years total), although none of our results are sensitive to this particular number of years. Standard errors are clustered by institution.

Figure 2 plots estimates of equation (1) for log institution spending, log tuition, and log enrollment, with coefficients arranged in event time so that positive indices correspond to lagged values of state appropriations. The top panel shows that increases in state support are correlated with contemporaneous increases in spending. The base year coefficient suggests that a 10 percent increase in appropriations in year t is associated with a 3 percent increase in spending in the same year. The middle panel shows that state funding is negatively correlated with tuition prices, with a 10 percent increase in appropriations linked to a price cut of about 0.6 percent. The bottom panel shows that increased appropriations are also associated with increased enrollment.

While these estimates show that institution outcomes change contemporaneously with state appropriations, Figure 2 also reveals significant pre-trends in these relationships. The coefficients on the first lead of appropriations indicate that spending and enrollment rise in the year prior to an increase in state support, while tuition falls. This pattern may reflect funding decisions that anticipate changes in the demand for higher education. For example, state legislatures may allocate more funds for higher education when enrollment is projected to grow quickly, or target extra funds to institutions where enrollment demand is growing especially fast. These pre-trends suggest that estimates of equation (1) are unlikely to capture causal effects of appropriations.

3.2 State Budget Shocks

As discussed above, state budget changes are typically - but not always - made "across the board" (e.g. all institutions in the state receive 90 percent of their funding requests). However, an across-the-board budget cut is likely to have a greater proportional impact on institutions that derive a larger share of revenue from state appropriations. We exploit historical differences across institutions in their reliance on state revenue to estimate the impact of funding changes. Our approach here is similar to "shift-share" style identification strategies that have been used to study the effects of local labor market conditions, immigration flows, and exposure to international trade (Bartik, 1991; Blanchard and Katz, 1992; Card, 2001; Autor et al., 2013).

We construct a state budget shock variable that multiplies yearly state appropriations by each public institution's share of total revenue from state appropriations in 1990, the first year that IPEDS data are available. The budget shock is defined as:

$$Z_{i,t} = \left(\frac{Approp_{i,90}}{Rev_{i,90}} \right) \times \left(\frac{StApprop_{s(i),t}}{Pop_{s(i),t}} \right), \tag{2}$$

where $Approp_{i,90}$ and $Rev_{i,90}$ measure state appropriations and total revenue for institution i in 1990, $s(i)$

denotes state for institution i, and $StApprop_{s,t}$ and $Pop_{s,t}$ represent total appropriations and college-age population for state s in year t. The first factor in (2) is each institution's revenue from state appropriations divided by total revenue in 1990. This captures a school's dependence on state funds at baseline. Using the 1990 revenue shares shuts down variation in exposure to state budget shocks that might be driven by endogenous institutional responses. For example, institutions might become more or less dependent on state appropriations over time based on changing selectivity, increased ability to attract out-of-state students, or other sources of unobserved heterogeneity.

The second factor in (2) calculates state appropriations per college-age (age 19-23) student in each state and year, using Grapevine data rather than institution-level appropriations from IPEDS. Restricting variation in state appropriations to the state-year level addresses the concern that schools receiving more or less funding within a particular state and year may differ in unobserved ways. For example, a budget cut for an individual institution may be more or less severe depending on the current political influence of its leadership. State legislatures might allocate additional funds to colleges in labor markets that have been hit particularly hard by economic downturns.

To give a sense for which colleges are most affected by state budget shocks, Appendix Table 2 presents estimates of the correlation between institutional characteristics and baseline dependence on state appropriations (the first term in $Z_{i,t}$ above) in a regression framework. Four-year, less-selective institutions are most reliant on state appropriations, for two reasons. First, many two-year colleges also receive funding from property taxes and other local sources. Second, selective four-year institutions are generally larger and have other sources of revenue such as research grants and endowment spending. Dependence on tuition revenue is also positively correlated with dependence on state appropriations, which is consistent with less-selective institutions having fewer ways to respond to a budget shock.

3.3 Impacts of State Budget Shocks on Institution Outcomes

We study the impact of state budget shocks by estimating equation (1) with leads and lags of $Z_{i,t}$ in place of appropriations $X_{i,t}$. We also add controls for a set of time-varying covariates including state and county unemployment rates by year, time-varying institution characteristics such as highest degree offered and eligibility to distribute Federal financial aid, county average demographic and economic characteristics, and interactions of these variables with time.[6] Our preferred specification also controls for state-specific linear time trends. Standard errors are clustered at the institution level. Here and in our subsequent results, we divide $Z_{i,t}$ by 1,000 for ease of interpretation.

The top panel of Figure 3 presents estimates of the effects of budget shocks on log enrollment. In contrast

[6]The institutional covariates are sector, highest degree offered, Title IV eligibility, degree-granting status, urban status and indicators for missing values of these covariates in each year. These covariates rarely change within institutions over time, but we include them for completeness. The county covariates are log population, percent black, percent hispanic, percent male, percent below the poverty line, log median income, share with some college education, and share with bachelor's degree. County covariates are only available from the U.S. Census for 1990 and 2000, and from the ACS for 2005 and onward. To complete the county data, we linearly interpolate values for missing years.

to the results using actual appropriations in Figure 2, we find no evidence of pre-trends in the relationship between the budget shock and enrollment. The coefficients on all four leads are precisely estimated, near zero and not statistically significant. We fail to reject the hypothesis that all four pre-trend coefficients are jointly equal to zero ($p = 0.64$). Additionally, we find a positive impact of the budget shock on log enrollment in the following academic year. This estimate, which is statistically significant at the one percent level, implies that a $1,000 increase in the budget shock increases enrollment by 2.8 percent. Like other shift-share measures, the budget shock variable does not have a natural scale; we follow Autor et al.'s (2013) approach to interpreting the effects of their measure of trade with China and scale our estimates by the interquartile range of the shock. The interquartile range of $Z_{i,t}$ is 1.1, so our estimate implies that a movement from the 25th to the 75th percentile of the budget shock causes a 3.1 percent increase in enrollment in the same academic year. This equals 253 students at the sample mean enrollment value of 8,172.

We also find effects of the budget shock on enrollment in future years. The estimated effects of a budget increase in year t are positive in years $t+1$ through $t+5$, and the estimates in years 1, 3, and 5 are statistically significant. The magnitudes of the coefficients indicate that a movement from the 25th to the 75th percentile of $Z_{i,t}$ increases total enrollment over the subsequent five years by about 1.4 percent, or 570 students. Overall, the magnitudes in the top panel of Figure 3 are roughly in line with the simple time series pattern in Figure 1, which shows that enrollment declines by 1-2 percent in the years immediately following a budget cut of 15 percent or more. The mean value of $Z_{i,t}$ (in thousands) is 1.87, so our estimates indicate that a 15 percent change in the budget shock results in an enrollment change of roughly $1.85 \cdot 0.15 \cdot 0.028 \times 100 = 0.8$ percent.

The bottom panel of Figure 3 repeats the exercise for another key outcome - the log of total degrees and certificates awarded. While the contemporaneous impact of the budget shock instrument on degrees and certificates is small, we find a large, statistically significant, positive impact of a budget shock in year t on log awards in year $t + 1$. The magnitude implies that a movement from the 25th to the 75th percentile of $Z_{i,t}$ increases total awards by 5 percent in the year after the shock, which equals about 55 additional degrees at the mean value of awards. The other post-shock coefficients are mostly positive, and we decisively reject the joint hypothesis that the coefficients on degrees and certificates in years t through $t + 5$ all equal zero ($p = 0.001$). As with the enrollment results, these estimates are qualitatively in line with the time series relationship between budget cuts and degrees depicted in Figure 1, which shows a pronounced decrease in awards in the year following a large budget cut. Additionally, we fail to reject the joint hypothesis that the pre-trend coefficients are equal to zero ($p = 0.35$) and there is no visual evidence of pre-trends.

An institution that faces a state budget cut can either reduce spending or increase tuition to maintain spending. Thus it is plausible that institutional spending and tuition are the two key mechanisms through which budget shocks affect enrollment and degree completion. Figure 4 presents event study estimates of the effects of budget shocks on log total spending and log tuition. The top panel of shows clear evidence that an increase in $Z_{i,t}$ boosts total spending in year t. We also find smaller but still statistically significant impacts on spending in the second and fifth years following the budget shock. The bottom panel shows that

state budget shocks affect tuition as well. The magnitudes of these estimates imply that moving from the 25th to the 75th percentile of the budget shock causes roughly a 6 percent increase in spending and a 6 percent reduction in tuition. This suggests that public institutions may react to state budget cuts in part by increasing tuition to make up for lost revenue. In the next section we explore the contributions of these two channels to the attainment effects displayed in Figures 3 and 4.

4 Mechanisms

4.1 Spending and Tuition

The results in Figure 4 show that institutions react to budget cuts through a mix of price increases and spending cuts. The effect of a budget shock on educational attainment therefore measures the net impact of adjustments on both of these margins. We would ideally like to study the impacts of changes in spending versus price among institutions that are forced to make only one adjustment, holding the other constant. We approximate this ideal by introducing a second source of variation based on tuition cap and freeze regulations, which constrain institutions' ability to adjust prices in response to budget cuts. The combination of budget shocks and tuition regulations produces independent variation in spending and prices, allow us to get a sense of which causal mechanism is most important in explaining the reduced form effects of budget shocks.

Seventeen states imposed formal price controls on public institutions at least once between 1990 and 2013. The complete list appears in Appendix Table A3. We compiled these data by referencing official sources when available, combined with Lexis-Nexis searches of state newspapers going back to 1990. Across all years in our sample, about 9 percent of students were enrolled in public institutions operating under a legislative tuition cap or freeze.

We use this tuition regulations to construct two instruments for price. The first, $TuitCap_{i,t}$, equals one if institution i is subject to a cap or freeze in year t. The second, $TuitMax_{i,t}$, equals the maximum percentage increase allowed by the state legislature between years $t-1$ and t for institution i. For example, this variable equals zero for institutions subject to tuition freezes, and 0.1 for institutions where tuition growth is constrained to no more than 10 percent. We include both of these variables in our estimating equations and code $TuitMax_{i,t}$ to zero for cases where $TuitCap_{i,t} = 0$. The combination allows us to exploit variation in both the existence and intensity of tuition cap legislation. Appendix Figures A2 and A3 show an absence of differential pre-trends between institutions that are and are not subject to tuition regulations, suggesting that these variables provide a clean experiment for tuition prices.

We use the budget shock and price cap variables as instruments in a two-stage least squares (2SLS) system estimated in first differences, with changes in log spending and tuition treated as endogenous explanatory variables. The first stage equation for log spending is:

$$\triangle \log spend_{i,t} = \phi_{s(i)} + \omega_t + \Delta W'_{i,t}\lambda + \pi_1 \triangle Z_{i,t} + \pi_2 \triangle TuitCap_{i,t} + \pi_3 \triangle TuitMax_{i,t} + \eta_{i,t}. \quad (3)$$

This equation relates the change in spending relative to the previous year to changes in the budget shock and tuition cap instruments, controlling for state and year fixed effects and changes in covariates. The first stage equation for changes in tuition replaces the change in log spending with the change in log tuition on the left-hand side of (3). The second stage equation is:

$$\triangle Y_{i,t} = \Phi_{s(i)} + \Omega_t + \Delta W'_{i,t}\Lambda + \beta_1 \Delta \log \widehat{spend}_{i,t} + \beta_2 \Delta \log \widehat{tuition}_{i,t} + \epsilon_{i,t}, \tag{4}$$

where $\Delta \log \widehat{spend}_{i,t}$ and $\Delta \log \widehat{tuition}_{i,t}$ are predicted changes in log spending and log tuition from the first stage. Relative to the fixed effects specification in equation (1), these first-differenced models focus on sharp yearly changes in budget shocks, tuition regulations, and outcomes. Appendix Table A4 shows that we obtain similar results from a variety of different methods of controlling for changes in outcomes over time.[7]

Columns (1) and (2) of Table 1 report first-stage impacts of the budget shock and tuition cap instruments on log spending and log tuition. Consistent with the event studies in Figure 4, the budget shock significantly increases spending and reduces tuition. Column (2) shows that the tuition regulation instruments have bite: a tuition freeze lowers in-state tuition by about 3 percent. Moreover, the stringency of the cap strongly predicts the size of the tuition change. A ten percentage point increase in maximum tuition growth leads to a 3 percent increase in tuition. Angrist and Pischke (2009) partial F-statistics indicate that the instruments generate substantial independent variation in log tuition and log spending.

The second-stage estimates show that state budget shocks affect enrollment and degree completion primarily through spending. Column (3) of Table 1 reveals that a 10 percent increase in log spending increases current-year enrollment by 3 percent, and this estimate is statistically significant at the 5 percent level. Columns (4) and (5) show that spending has a limited contemporaneous effect on degree completion but a large positive effect in the following year, a pattern that is similar to the reduced form effects of budget shocks shown in Figure 3. In contrast, the estimated elasticities with respect to tuition are close to zero and statistically insignificant in each model. Importantly, these null results for tuition hold despite the strong first stage predictive power of the instruments shown in column 2.

These results should not be interpreted as showing that tuition prices have no impact on educational attainment. Our estimates correspond to changes in sticker-price tuition for a particular set of schools subject to tuition regulations, and previous evidence establishes that tuition and financial aid affect choices in a variety of settings (Deming and Dynarski, 2010; Denning, 2017; Denning et al., 2017). Moreover, we cannot reject tuition elasticities on the order of -0.17 for enrollment and -0.13 for degree completion, which are in the range reported in the previous literature (see, e.g., Hemelt and Marcotte, 2011). Nonetheless, the estimates in Table 1 suggest that the large reduced form impacts of state budget shocks described in Section 3 are driven by changes in spending rather than tuition prices.

[7] Additionally, Appendix Table A5 shows that we find similar results in 2SLS models when we ignore endogeneity concerns and replace the change in the budget shock with the change in actual state appropriations.

4.2 Other Results and Discussion

Our findings can help explain several trends and stylized facts in U.S. higher education. The results suggest a causal link between sharp declines in state funding in the last twenty years and increases in time to degree and decreases in college completion rates over the same period (Turner, 2004; Bound et al., 2010, 2012).

Our results are consistent with the broad trend of informal capacity constraints in public institutions, including reduced course offerings, long waitlists, little or no student guidance, and larger class sizes (Bahr et al., 2013). Bound and Turner (2007) argue that informal capacity constraints caused by "cohort crowding" dilute college quality, while Bound et al. (2010) argue that resources per student and other supply side factors explain a large portion of the decline in college completion rates between 1972 and 1992. Bound et al. (2012) assemble qualitative evidence from 12 states which suggests that inadequate student advising, decreased course availability and overcrowding have contributed to recent increases in time to degree in public universities. Unfortunately, IPEDS data do not contain information about course waitlists or student advising loads. However, Appendix Table A7 shows that state budget shocks generate disproportionate increases in academic support spending compared to other spending categories. Taken together, these findings are consistent with the importance of academic support resources for degree attainment.

A key question is whether changes in state support for public institutions generates spillover impacts on other nearby institutions. Our estimates could reflect movement of students across institutions rather than net changes in enrollment and degree receipt in response to funding shocks. Appendix Tables A8 and A9 investigate spillovers on private and public institutions by relating changes in outcomes to the (enrollment-weighted) average budget shock for all public institutions in the same county. Table A8 suggests that spillovers for private institutions are limited: while there is some evidence of a contemporaneous effect on private enrollment, estimates for later years yields spillover effects that are near zero and sometimes in the wrong direction. The estimates using county-level spending shocks for public institutions in Table A9 are very similar to our main results, although somewhat larger in magnitude. This suggests that our findings are not driven by students sorting across nearby public institutions in response to funding shocks.

While it is easy to understand how price changes could affect student enrollment choices, the impact of spending is less obvious. One possibility is that students observe spending increases through smaller classes, increased course offerings or other amenities, and make matriculation decisions accordingly. This seems unlikely to be the main explanation for our results, for two reasons. First, Appendix Table A10 shows positive and statistically significant impacts on bachelor's degrees in the second and third years following a budget shock. Since median time to bachelor's degree completion in the U.S. is about five years, impacts in earlier years suggest that the mechanism is persistence among already-enrolled students. Second, in Appendix Table A11 we present suggestive evidence of larger impacts on enrollment for upper division students compared to freshmen.

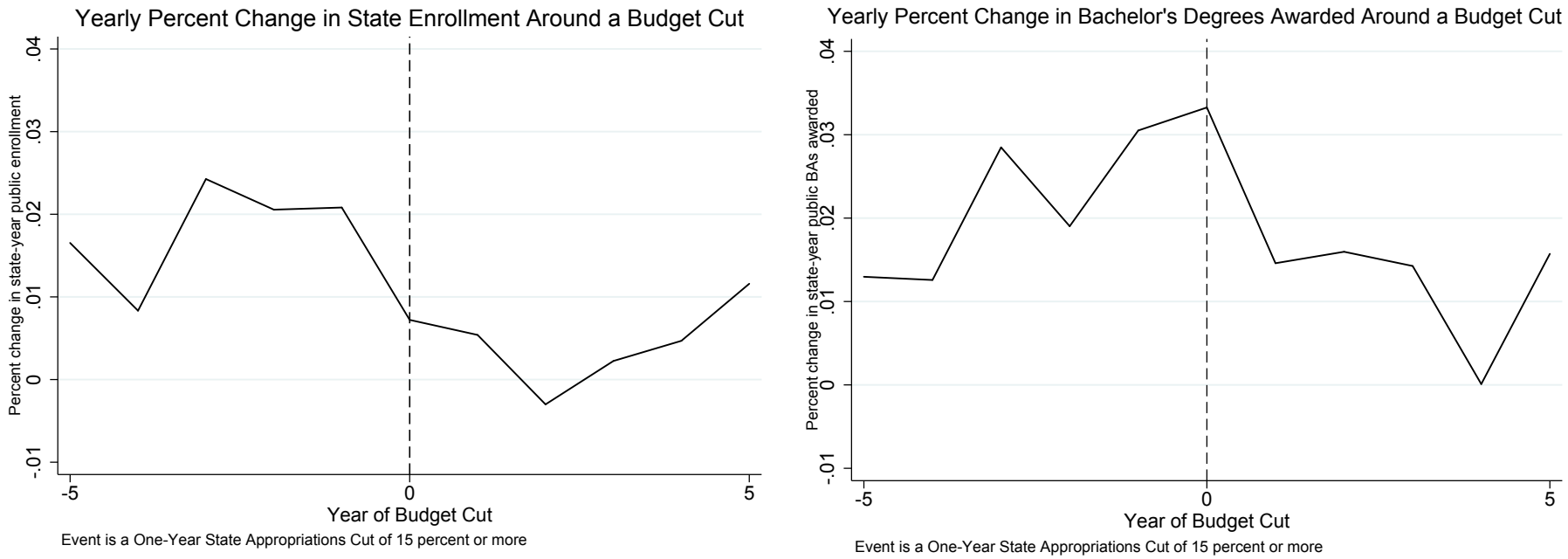
5 Conclusion

This paper studies the impact of higher education budget cuts on U.S. postsecondary attainment. Using exogenous variation in funding driven by differences across institutions in historical reliance on state appropriations, we find large impacts of budget cuts on enrollment and degree completion. While budget cuts are sometimes passed on as higher tuition prices, we find that most of the impact of budget shocks on postsecondary attainment can be explained by spending cuts (holding prices constant). Our findings hold for both two-year and four-year institutions and across all types of postsecondary awards, including bachelor's degrees.

Over the last two decades, higher education funding and per-student spending have declined in most states (Baum and Ma 2014). Our results demonstrate a causal connection between budget cuts, higher college dropout rates, and the slowdown in the growth of postsecondary attainment in U.S. public institutions. Our findings also highlight a possible tension between price and spending subsidies for higher education. We find that most of the impact of budget cuts can be explained by spending cuts rather than price increases, yet nearly all Federal subsidies (and an increasing share at the state level) focus on lowering prices through financial aid grants and subsidized loans. Policymakers who want to subsidize spending increases rather than price cuts could provide a matching grant directly to public institutions, similar to the Federal Title I program for K-12 schooling (see, e.g., Deming, 2017)

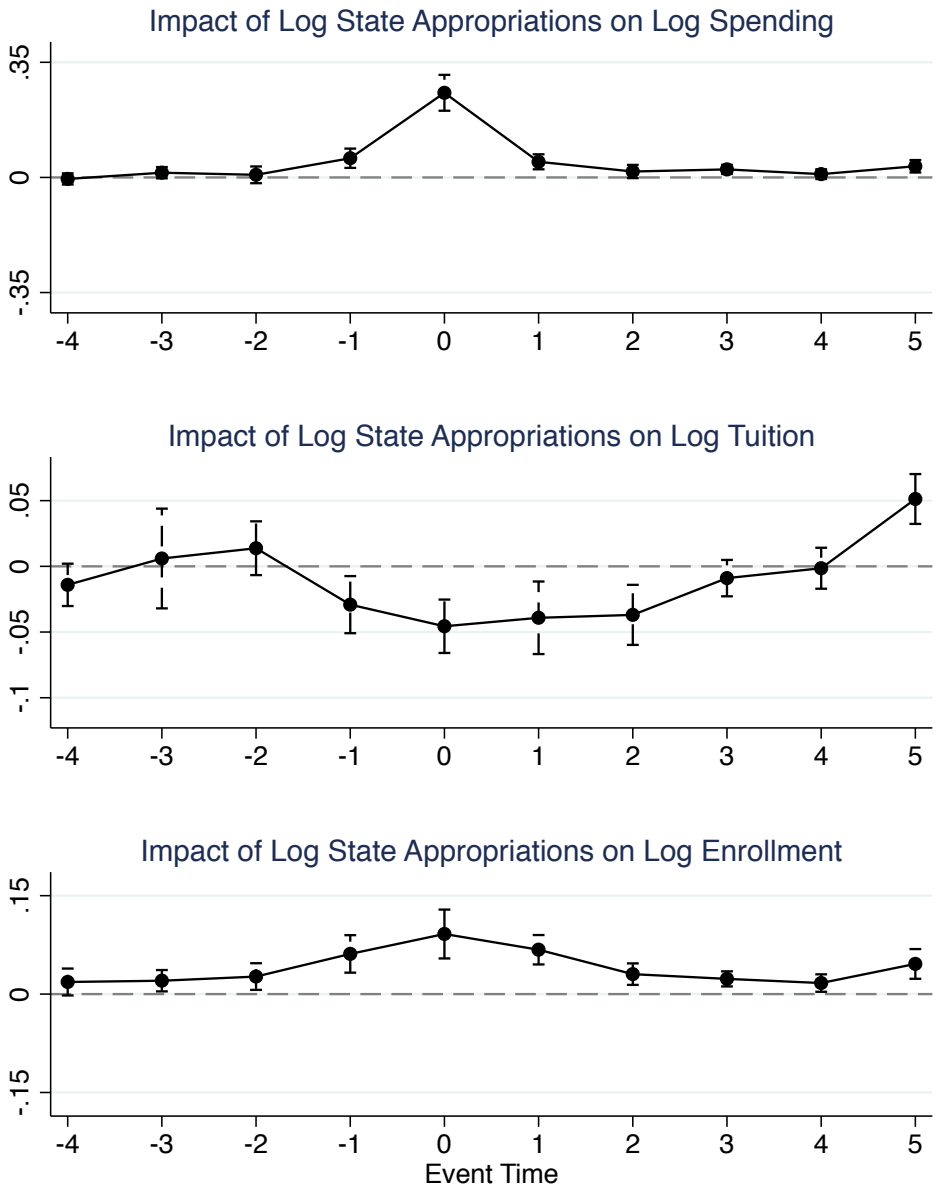
We find that budget cuts have large impacts on core spending categories such as instruction and student support, and large downstream impacts on postsecondary attainment. Thus contrary to the narrative of administrative bloat, higher education budget cuts are "to the bone". An important caveat is that our results are identified mostly from variation within non-selective public institutions, where per-student spending is relatively low and extravagant consumption amenities are rarely found.

Figure 1



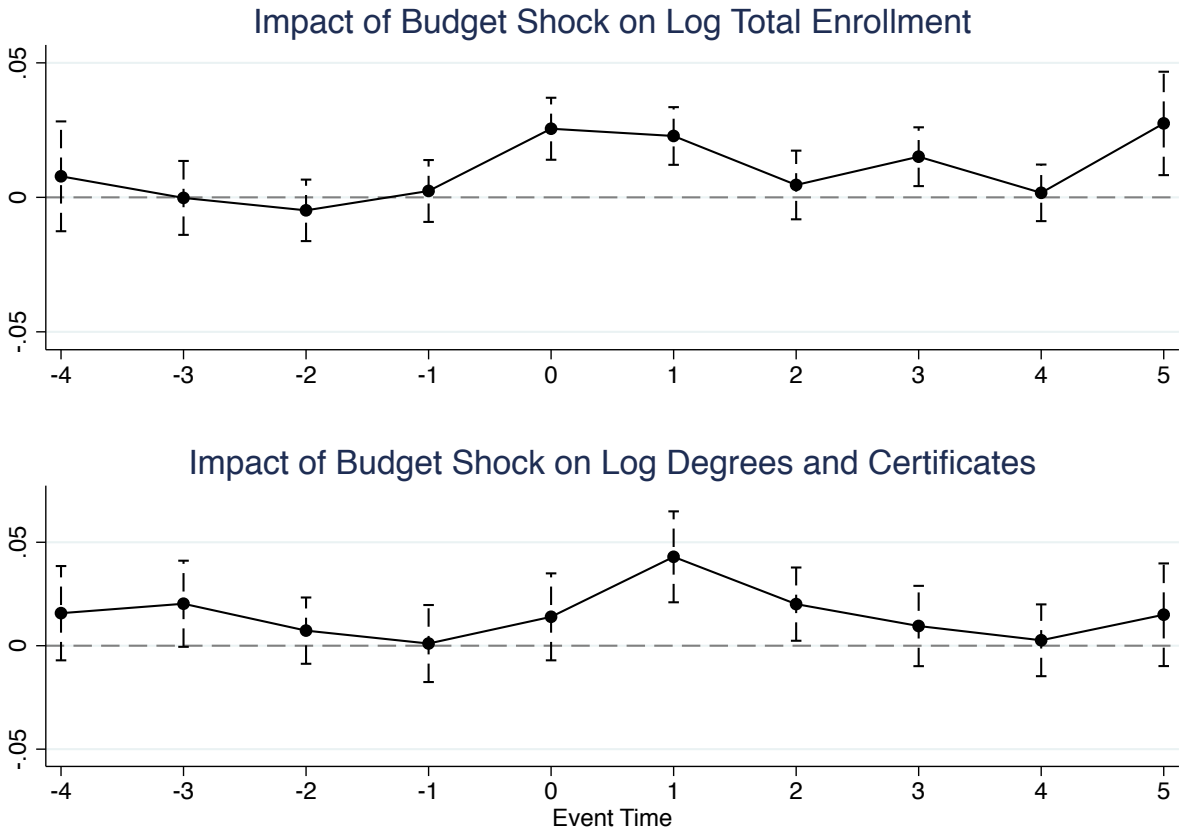
Notes: This figure displays yearly enrollment growth (left-hand panel) and growth in bachelor's degrees awarded (right-hand panel) for public institutions for five years before and after a cut in state appropriations of 15 percent or more. The sample includes all public institutions that experienced a 15 percent cut in state support in any single year between 1990 and 2013.

Figure 2



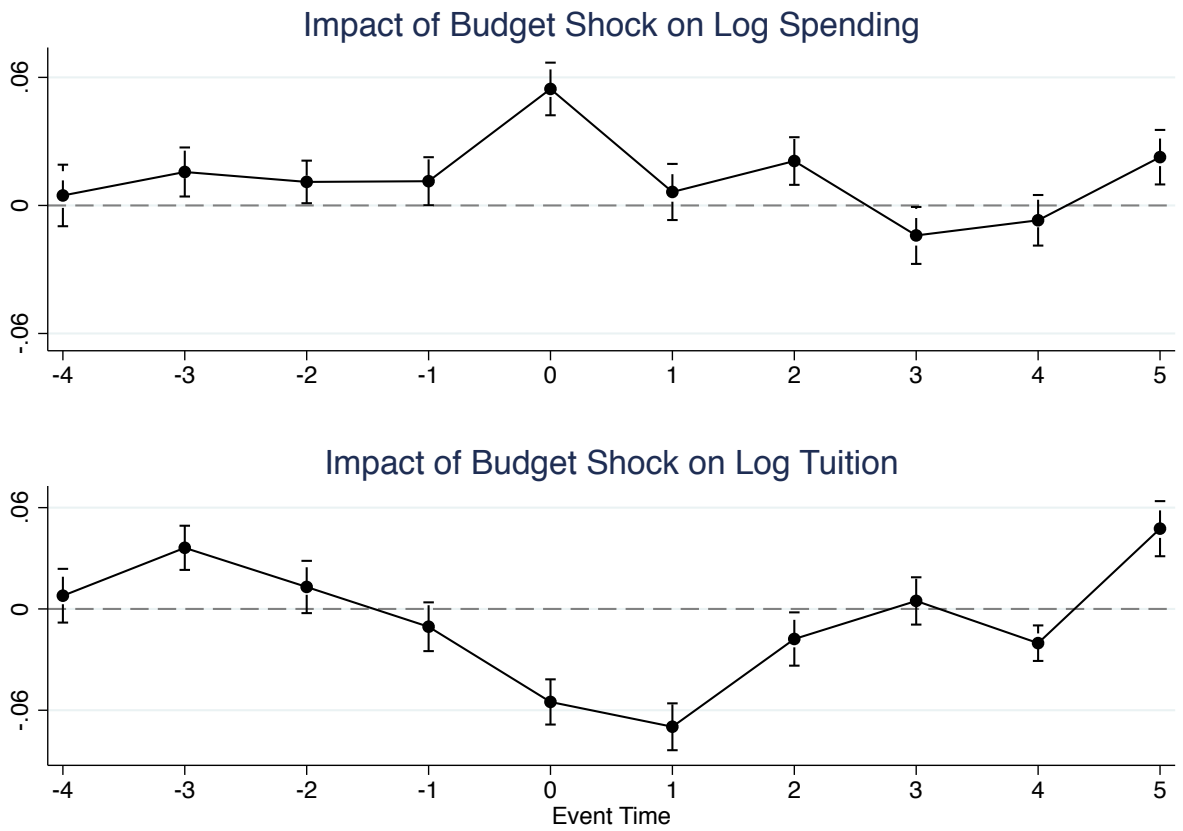
Notes: This figure presents estimates and 95 percent confidence intervals from regressions of log total spending (top panel), log tuition (middle panel), and log enrollment (bottom panel) on lags and leads of state appropriations for public institutions. Models also control for institution and year fixed effects. Standard errors are clustered at the institution level.

Figure 3



Notes: This figure presents estimates and 95 percent confidence intervals from regressions of log enrollment (top panel) and log total degrees and certificates awarded (bottom panel) on lags and leads of the state budget shock (the share of each institution's revenue from state appropriations in 1990 times yearly state appropriations per capita, in $1000s). The model also controls for lags and leads of county and state unemployment rates, time-varying county and institution characteristics, institution fixed effects, year fixed effects, and state-specific time trends. Standard errors are clustered at the institution level.

Figure 4



Notes: This figure presents estimates and 95 percent confidence intervals from regressions of log total spending (top panel) and log tuition (bottom panel) on lags and leads of the state budget shock (the share of each institution's revenue from state appropriations in 1990 times yearly state appropriations per capita, in $1000s). The model also controls for lags and leads of county and state unemployment rates, time-varying county and institution characteristics, institution fixed effects, year fixed effects, and state-specific time trends. Standard errors are clustered at the institution level.

Table 1 - Two-stage least squares estimates of the effects of tuition and spending on enrollment and degrees

	First stage		Second stage		
	Log spending	Log tuition	Log enrollment	Log awards: current year	Log awards: year T+1
	(1)	(2)	(3)	(4)	(5)
Budget shock instrument	0.061***	-0.081***			
	(0.004)	(0.007)			
Any tuition cap	0.001	-0.030***			
	(0.002)	(0.003)			
Maximum increase	-0.045*	0.304***			
	(0.027)	(0.056)			
Log total spending			0.300**	0.201	0.779**
			(0.134)	(0.259)	(0.317)
Log tuition			-0.017	0.115	0.226
			(0.076)	(0.151)	(0.178)
AP partial *F* -statistic	26.6	58.2			
Sample size	27659	27659	27659	28108	26834

Notes : This table reports two-stage least squares estimates of the effects of tuition and spending on total fall enrollment and log degrees and certificates. In the first stage we regress each institution's yearly change in log total spending and log tuition on the change in the budget shock instrument (the share of each institution's revenue from state appropriations in 1990 times yearly state appropriations per capita, in $1000s), the change in an indicator for whether a tuition cap is in place in the current state and year, and the change in the maximum percentage increase allowed under the cap (set to zero when no cap is in place). The second stage regresses yearly changes in outcomes on predicted changes in tuition and spending from the first stage. Columns (1) and (2) report first stage results in the sample with observed enrollment. Columns (3)-(5) report second-stage estimates for log enrollment, log total degrees and certificates awarded in the current year, and log degrees and certificates the following year. Both stages control for time-varying county demographic and economic covariates, time-invariant institution characteristics, year effects, and state fixed effects. Standard errors, clustered at the institution level, are in parentheses. *significant at 10-percent; **significant at 5-percent; ***significant at 1-percent

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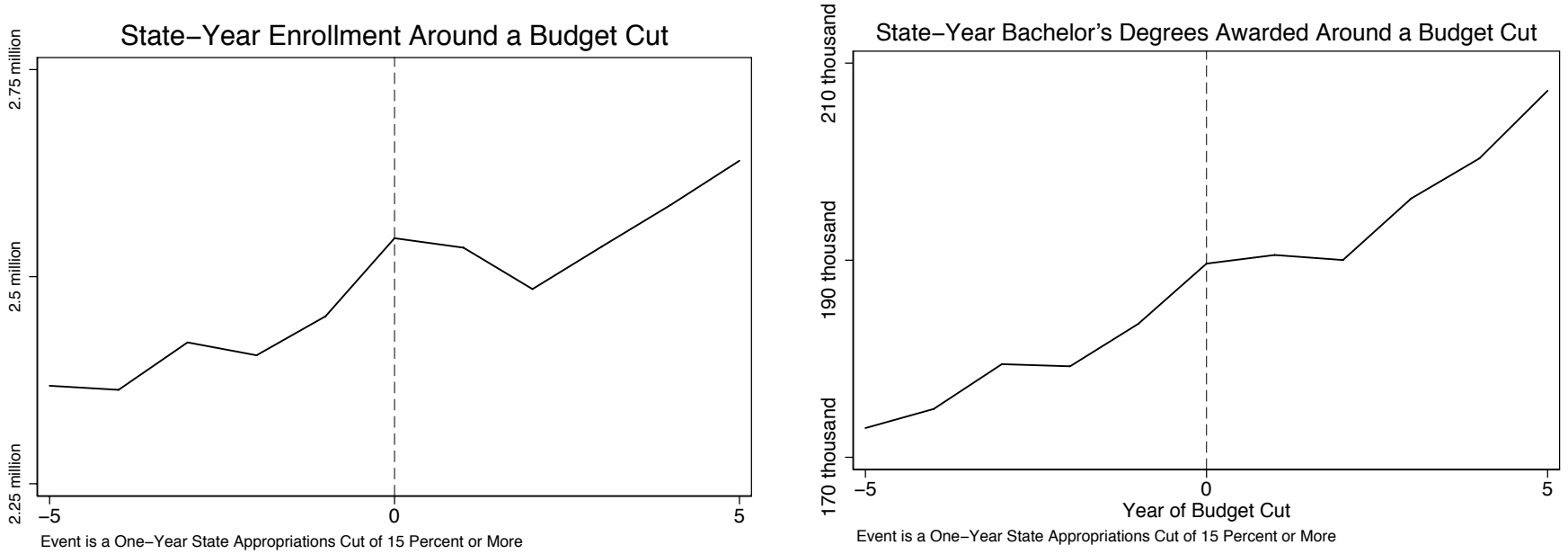
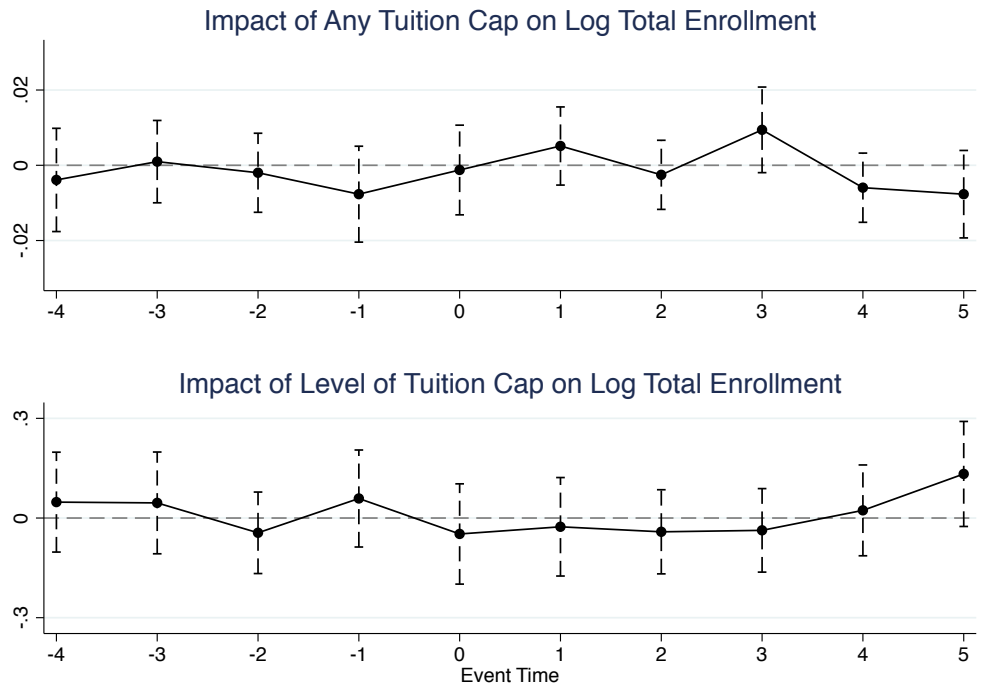
Figure A1



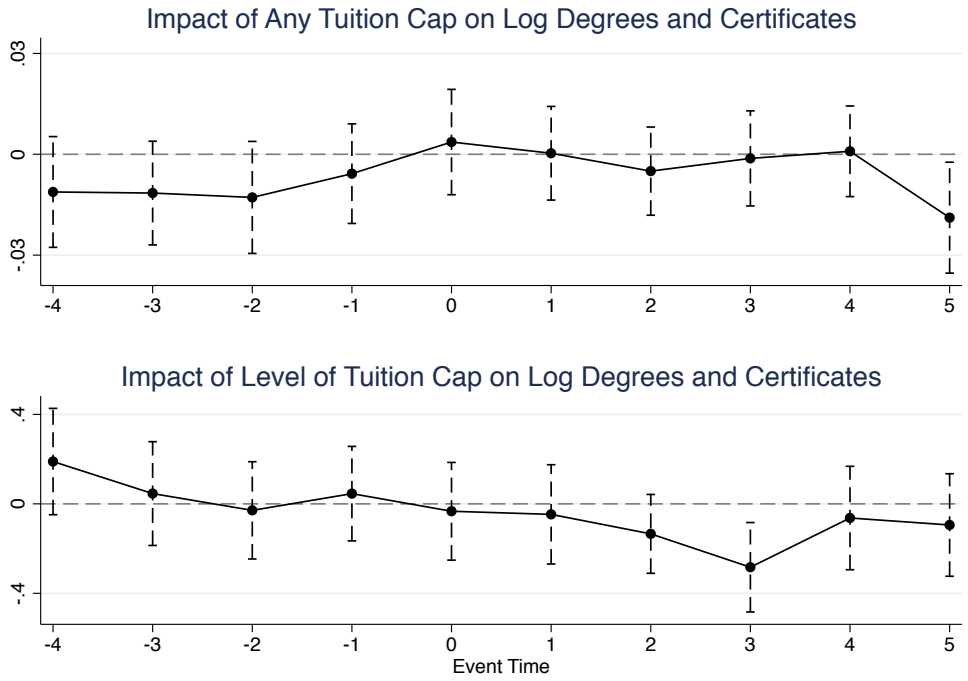
Notes: This figure displays levels of enrollment (left-hand panel) and e bachelor's degrees awarded (right-hand panel) for public institutions for five years before and after a cut in state appropriations of 15 percent or more. The sample includes all public institutions that experienced a 15 percent cut in state support in any single year between 1990 and 2013.

Figure A2



Notes: This figure presents estimates and 95 percent confidence intervals from a regression of log enrollment on lags and leads of tuition regulation variables. The top panel shows coefficients on an indicator for whether any tuition cap is in place, and the bottom panel shows coefficients on the maximum percentage increase allowed under the cap, coded to zero when no cap is in place. The model also controls for lags and leads of county and state unemployment rates, time-varying county and institution characteristics, institution fixed effects, year fixed effects, and state-specific time trends. Standard errors are clustered at the institution level.

Figure A3



Notes: This figure presents estimates and 95 percent confidence intervals from a regression of log total degrees and certificates awarded on lags and leads of tuition regulation variables. The top panel shows coefficients on an indicator for whether any tuition cap is in place, and the bottom panel shows coefficients on the maximum percentage increase allowed under the cap, coded to zero when no cap is in place. The model also controls for lags and leads of county and state unemployment rates, time-varying county and institution characteristics, institution fixed effects, year fixed effects, and state-specific time trends. Standard errors are clustered at the institution level.

Table A1 - Descriptive statistics

	1990			2013		
	Selective, four year	Nonselective, four year	Two year	Selective, four year	Nonselective, four year	Two year
	(1)	(2)	(3)	(4)	(5)	(6)
Tuition and fees	4,978	3,267	1,027	15,953	8,418	2,381
State appropriations	13,695	8,108	2,549	8,626	5,290	1,890
Local appropriations	45	105	1,013	0	108	1,455
Total grants	1,676	1,111	496	5,594	3,462	1,990
Instructional spending	11,142	6,472	2,606	15,738	7,491	3,007
Academic support	1,593	726	230	4,630	1,700	536
Student services	742	387	257	1,930	1,093	647
Administration	1,279	746	407	3,230	1,703	950
Scholarships	902	559	258	1,753	1,070	836
Total spending	31,946	16,147	5,672	45,584	20,172	7,441
Enrollment	21,278	9,306	3,626	25,865	11,752	5,451
Institution count	36	549	1,383	35	633	1,224

Notes: Table 1 presents average enrollment and financial statistics for U.S. public institutions. Data are from the Integrated Postsecondary Education Data System (IPEDS) for 1990 and 2013. Selective colleges are ranked as "Most Competitive" or "Highly Competitive" by the 2009 Barron's Profile of American Colleges. The column "Two Year" also contains a small number of public institutions that offer only less than two year credentials. The first five rows present categories of institutional revenue. The next three rows present categories of institutional spending, and the last two rows are total Fall enrollment and the number of institutions in each category respectively. All financial figures are in 2013 dollars. Total grants includes Federal sources such as the Pell grant, as well as state merit aid and private scholarships. The sample for columns (4)-(6) is restricted to institutions open in 1990.

Table A2 - Correlates of reliance on state appropriations

	All	Two year	Four year
	(1)	(2)	(3)
Two year	-0.457***		
	(0.107)		
Selective			-0.667***
			(0.124)
As a share of total spending:			
Tuition and fees	0.134***	-0.018	0.276***
	(0.029)	(0.040)	(0.060)
State appropriations	0.605***	0.472***	0.628***
	(0.029)	(0.052)	(0.043)
Local appropriations	-0.399***	-0.337***	-0.031*
	(0.034)	(0.055)	(0.018)
Total grants	0.040***	0.028	0.151***
	(0.015)	(0.018)	(0.030)
Instructional spending	0.067***	0.062***	0.156***
	(0.016)	(0.020)	(0.030)
Academic support	0.022***	0.011	0.021
	(0.006)	(0.008)	(0.014)
Student services	0.012*	0.002	0.050***
	(0.007)	(0.008)	(0.018)
Administration	-0.012	-0.030***	0.055***
	(0.009)	(0.010)	(0.019)
Scholarships	0.013*	0.017*	0.069***
	(0.008)	(0.010)	(0.013)
Log total spending	-0.612***	-0.204	-2.884***
	(0.203)	(0.130)	(0.381)
Log enrollment	-0.322	-0.572*	-0.699
	(0.242)	(0.342)	(0.455)
Sample size	30072	17568	12504

Notes: This table describes relationships between public institution characteristics and reliance on state appropriations, defined as the share of each institution's revenue from state appropriations in 1990. Each row shows the coefficient from a regression of a characteristic on this measure of reliance using data from 1991-2013, controlling for state effects and year effects. Column (1) shows results for all public institutions, column (2) shows results for two year institutions, and column (3) shows results for four year institutions. Standard errors, clustered at the institution level, are in parentheses.

*significant at 10-percent; **significant at 5-percent; ***significant at 1-percent

Table A3 - List of tuition caps and freezes by state, 1990-2013

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Alabama[2]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	--	--	--
Alaska	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arizona	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arkansas	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
California	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Colorado	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Connecticut[1]	--	--	--	--	--	--	--	--	--	--	0	--	--	--	--	--	--	--	--	--	--	--	0	--
Delaware	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Florida	--	--	--	--	--	0	--	--	--	--	--	--	--	--	--	--	--	--	0	--	--	--	--	--
Georgia	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hawaii	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Idaho	--	--	--	--	--	--	--	--	--	--	--	--	--	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	--	0.1	0.1
Illinois	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indiana	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Iowa	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Kansas	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Kentucky	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Louisiana	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Maine[2]	--	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0	--	--	--	--	--	0	--	0
Maryland[1]	--	--	--	--	--	--	--	--	0.04	0.04	0.04	0.04	0.04	--	--	--	--	0	0	0	0	0.03	0.03	0.03
Massachusetts	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Michigan	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Minnesota	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mississippi	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Missouri[1]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	--	--
Montana	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	--	--	--	--
Nebraska	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Nevada	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
New Hampshire[2]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	--	0	--	--	--	0
New Jersey[1]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.09	0.08	0.08	0.08	--	--	0.03	0.04	--	--
New Mexico	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
New York[3]	--	--	--	--	0	0	--	0	0	0	0	0	0	0	--	0	0	0	0	0	--	--	--	--
North Carolina[1]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	--	--	0	--	--	0.065	--
North Dakota	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ohio	--	--	--	--	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	--	--	--	0.06	0.06	0.035	0.035	0.035	0.035	0.035	0.035
Oklahoma[4]	--	--	--	--	--	--	--	--	--	--	--	--	0.07	0.07	--	--	--	--	--	--	0	--	--	--
Oregon[1]	--	--	--	--	--	--	--	--	0	0	0	0	--	--	--	--	0.03	0.03	--	--	--	--	--	--
Pennsylvania	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rhode Island	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
South Carolina	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
South Dakota	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tennessee	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Texas	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Utah	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vermont	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Virginia	--	--	--	--	--	0.03	0.03	0	0	0	-0.2	0	0	--	--	--	--	--	0.06	0.04	--	--	--	--
Washington	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
West Virginia	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Wisconsin[1]	--	--	--	--	--	--	--	--	--	--	--	0	--	0.08	--	--	--	--	--	--	--	--	0.055	0.055
Wyoming	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Notes : This table lists states and years where state legislatures impose in-state tuition caps and freezes at public institutions. We compiled these data by referencing official sources when available, combined with Lexis-Nexis searches of state newspapers going back to 1990. In some cases we checked actual tuition data to confirm the imposition of a cap, although in no case did we code a tuition cap or freeze unless it could be independently verified. 1 - Applies only to four-year institutions in the state. 2 - Applies only to two-year institutions in the state. 3 - Applies only to CUNY (except 2003) and Cornell (all years). 4 - Applies to all institutions except the Oklahoma Technology Centers.

Table A4 - Alternative state-by-time controls

Outcome is log enrollment	Log Spending	Log Tuition
	(1)	(2)
Changes, state effects	0.300**	-0.017
(baseline model)	(0.134)	(0.076)
Changes, state trends	0.268	-0.037
	(0.166)	(0.080)
Changes, state-by-four-year effects	0.244	-0.046
	(0.158)	(0.081)
Changes, institution effects	0.330**	-0.014
	(0.145)	(0.075)
Levels, institution effects	0.417***	-0.051
	(0.081)	(0.164)
Levels, institution effects	0.380***	-0.111
and state trends	(0.124)	(0.104)
Levels, institution effects	0.287	-0.160
and state-by-four-year effects	(0.274)	(0.212)
Sample size	27659	

Notes : This table reports two-stage least squares estimates of the effects of tuition and spending on log total fall enrollment with alternative controls for state-by-time variation in outcomes. "Changes" specifications use the yearly change in log enrollment as the dependent variable and changes in log tuition and log spending as the endogenous regressors, instrumenting with the change in the budget shock instrument, the change in whether a tuition cap is in place, and the change in the maximum percentage increase allowed under the cap (set to zero when no cap is in place). "Levels" specifications use log enrollment as the dependent variable, log tuition and log spending as endogenous regressors, and the budget shock, presence of a tution cap, and level of the cap as instruments. "Changes" models control for time-varying county demographic and economic covariates, time-invariant institution characteristics, and year effects, while "levels" models controls for time-varying county demographic and economic covariates, institution characteristics interacted with a time trend, and year effects. Standard errors, clustered at the institution level, are in parentheses.

*significant at 10-percent; **significant at 5-percent; ***significant at 1-percent

Table A5 - 2SLS estimates of the effects of spending and tuition based on appropriations

	Current year	T+1	T+2	T+3
Panel A: log enrollment	(1)	(2)	(3)	(4)
Log total spending	0.331***	0.563***	0.480***	0.344***
	(0.095)	(0.079)	(0.080)	(0.064)
Log tuition	-0.021	0.030	-0.031	-0.139
	(0.064)	(0.077)	(0.087)	(0.095)
Sample size	28197	26958	25687	24422
Panel B: log total awards				
Log total spending	0.473***	0.666***	0.514***	0.483***
	(0.123)	(0.120)	(0.119)	(0.104)
Log tuition	0.153	0.207	0.111	-0.041
	(0.131)	(0.146)	(0.146)	(0.149)
Sample size	28108	26834	25564	24304

Notes : This table reports two-stage least squares estimates of the effects of tuition and spending on total enrollment and log total awards using actual appropriations rather than the budget shock to instrument for spending. In the first stage we regress each institution's yearly change in log spending and log tuition on the change in their actual log appropriations, the change in an indicator for whether a tuition cap is in place in the current state and year, and the change in the maximum percentage increase allowed under the cap (set to zero when no cap is in place). The second stage regresses each institution's yearly changes in outcomes on predicted changes in log spending and tuition from the first stage. Panel A reports results for log enrollment, and Panel B reports results for log total awards. Both stages also control for time-varying county demographic and economic covariates, time-invariant institution characteristics such as sector, selectivity and highest degree offered, year fixed effects, and state fixed effects. Standard errors, clustered at the institution level, are in parentheses.
*significant at 10-percent; **significant at 5-percent; ***significant at 1-percent

Table A6 - Two-stage least squares estimates by year and institution type

	Current year	T+1	T+2	T+3
	(1)	(2)	(3)	(4)
Panel A: all institutions				
Log total spending	0.304**	0.796***	0.845***	0.830***
	(0.131)	(0.181)	(0.207)	(0.207)
Log tuition	-0.016	0.066	0.031	-0.073
	(0.072)	(0.100)	(0.118)	(0.123)
Sample Size	28197	26958	25687	24422
Panel B: two-year institutions				
Log total spending	0.283	1.020***	1.052***	0.951***
	(0.253)	(0.315)	(0.371)	(0.345)
Log tuition	-0.083	0.097	0.087	-0.100
	(0.133)	(0.169)	(0.201)	(0.204)
Sample Size	16800	16109	15389	14664
Panel C: four-year institutions				
Log total spending	0.239***	0.472***	0.662***	0.574***
	(0.081)	(0.129)	(0.164)	(0.182)
Log tuition	0.005	-0.039	-0.046	-0.127
	(0.060)	(0.085)	(0.111)	(0.116)
Sample size	11397	10849	10298	9758

Notes : This table reports two-stage least squares estimates of the effects of tuition and spending on log total fall enrollment by year and type of public institution. In the first stage we regress each institution's yearly change in log total spending and log tuition on the change in the budget shock instrument (the share of each institution's revenue from state appropriations in 1990 times yearly state appropriations per capita), the change in an indicator for whether a tuition cap is in place in the current state and year, and the change in the maximum percentage increase allowed under the cap (set to zero when no cap is in place). The second stage regresses each institution's yearly change in log enrollment on the changes in tuition and spending from the first stage. Panel A reports results for all institutions, while Panels B and C show results for two-year and four-year institutions respectively. Both stages also control for time-varying county demographic and economic covariates, time-invariant institution characteristics, year effects, and state fixed effects. Standard errors, clustered at the institution level, are in parentheses.

*significant at 10-percent; **significant at 5-percent; ***significant at 1-percent

Table A7 - 2SLS estimates of the impacts of tuition and spending on spending and revenue categories

	Financial aid			Spending categories		
	Scholarship aid	Pell Grant aid	Total aid	Instruction	Academic support	Student services
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: all institutions						
Log total spending	0.287	-0.389*	0.053	0.974***	1.716***	1.043***
	(0.687)	(0.227)	(0.347)	(0.124)	(0.378)	(0.252)
Log tuition	-0.536	-0.195	-0.143	-0.037	0.364	0.019
	(0.460)	(0.131)	(0.200)	(0.075)	(0.233)	(0.137)
Sample size	27634	27795	28135	28204	28126	28164
Panel B: two-year institutions						
Log total spending	-0.117	-0.466	0.159	0.958***	1.180*	1.076***
	(0.964)	(0.410)	(0.418)	(0.195)	(0.689)	(0.391)
Log tuition	-0.737	-0.153	-0.097	-0.027	0.163	0.111
	(0.593)	(0.223)	(0.190)	(0.106)	(0.400)	(0.210)
Sample size	16337	16502	16746	16812	16741	16774
Panel C: four-year institutions						
Log total spending	1.320**	-0.160	0.298	0.920***	1.685***	1.166***
	(0.624)	(0.184)	(0.333)	(0.110)	(0.286)	(0.271)
Log tuition	-0.101	-0.296**	-0.076	-0.102	0.153	0.036
	(0.525)	(0.127)	(0.265)	(0.086)	(0.215)	(0.157)
Sample size	11297	11293	11389	11392	11385	11390

Notes : This table reports two-stage least squares estimates of the effects of tuition and spending on institutional scholarship aid, Pell grant aid, and categories of spending. In the first stage we regress each institution's yearly change in log total spending and log tuition on the change in the budget shock instrument (the share of each institution's revenue from state appropriations in 1990 times yearly state appropriations per capita), the change in an indicator for whether a tuition cap is in place in the current state and year, and the change in the maximum percentage increase allowed under the cap (set to zero when no cap is in place). The second stage regresses each institution's yearly change in each spending category on the changes in tuition and spending from the first stage. Panel A reports all public institutions, while Panels B and C report results for two-year and four-year institutions. Both stages also control for time-varying county demographic and economic covariates, time-invariant institution characteristics such as sector, selectivity and highest degree offered, year fixed effects, and state fixed effects. Standard errors, clustered at the institution level, are in parentheses.

*significant at 10-percent; **significant at 5-percent; ***significant at 1-percent

Table A8 - Spillover impacts of public budget shocks on outcomes in private institutions

Panel A: log enrollment	Current year	T+1	T+2	T+3
	(1)	(2)	(3)	(4)
County average budget shock	-0.025*	-0.011	0.000	-0.027
	(0.014)	(0.018)	(0.022)	(0.024)
Any tuition cap	-0.002	-0.003	-0.013	-0.020**
	(0.006)	(0.008)	(0.008)	(0.009)
Sample size	55962	50018	44742	39855
Panel B: log total awards				
County average budget shock	-0.011	-0.049**	-0.041	-0.034
	(0.018)	(0.021)	(0.026)	(0.027)
Any tuition cap	0.002	-0.001	-0.015*	-0.016*
	(0.007)	(0.009)	(0.009)	(0.009)
Sample size	51066	45689	40865	36398
Panel C: log tuition				
County average budget shock	0.003	0.007	0.009	0.020
	(0.008)	(0.010)	(0.011)	(0.012)
Any tuition cap	0.002	-0.001	0.003	-0.001
	(0.003)	(0.003)	(0.004)	(0.004)
Sample Size	48794	43733	39353	35009

Notes : This table reports reduced form estimates of the impacts of the change in the average enrollment-weighted budget shock instrument (the share of each institution's revenue from state appropriations in 1990 times yearly state appropriations per capita) across public institutions in a county and the change in an indicator for whether any tuition cap is in place in the current state and year on the change in outcomes in private (not-for-profit and for-profit) institutions in the same county. Panels A, B, and C report results for log enrollment, log total awards, and log tuition. The regressions also control for time-varying county demographic and economic covariates, time-invariant institution characteristics such as sector, selectivity and highest degree offered, year fixed effects, and state fixed effects. Standard errors, clustered at the institution level, are in parentheses.

*significant at 10-percent; **significant at 5-percent; ***significant at 1-percent

Table A9 - Impacts of county-level budget shocks on outcomes in public institutions

Panel A: log enrollment	Current year	T+1	T+2	T+3
	(1)	(2)	(3)	(4)
Log total spending	0.528**	0.824***	1.141***	0.996***
	(0.209)	(0.250)	(0.312)	(0.292)
Log tuition	0.138	0.090	0.255	0.023
	(0.130)	(0.150)	(0.192)	(0.179)
Sample size	28197	26958	25687	24422
Panel B: log total awards				
Log total spending	0.139	0.819**	1.312***	1.171***
	(0.337)	(0.412)	(0.483)	(0.449)
Log tuition	0.073	0.199	0.402	0.369
	(0.210)	(0.244)	(0.298)	(0.273)
Sample size	28108	26834	25564	24304

Notes : This table reports reduced form estimates of the impacts of the change in the average enrollment-weighted budget shock instrument (the share of each institution's revenue from state appropriations in 1990 times yearly state appropriations per capita) across public institutions in a county and the change in an indicator for whether any tuition cap is in place in the current state and year on the change in outcomes for all public institutions in a county. Panels A and B report results for log enrollment and log total awards. The regressions also control for time-varying county demographic and economic covariates, time-invariant institution characteristics such as sector, selectivity and highest degree offered, year fixed effects, and state fixed effects. Standard errors, clustered at the institution level, are in parentheses.

*significant at 10-percent; **significant at 5-percent; ***significant at 1-percent

Table A10 - 2SLS estimates of the impacts of tuition and spending on log certificates and degrees by year

	Current year	T+1	T+2	T+3
Panel A: all institutions	(1)	(2)	(3)	(4)
Log total spending	0.201	0.779**	0.944***	0.645**
	(0.259)	(0.317)	(0.330)	(0.304)
Log tuition	0.115	0.226	0.184	-0.006
	(0.151)	(0.178)	(0.187)	(0.174)
Sample size	28108	26834	25564	24304
Panel B: two year institutions				
Log total spending	0.451	1.455**	1.459**	0.637
	(0.488)	(0.621)	(0.635)	(0.547)
Log tuition	0.264	0.445	0.244	-0.291
	(0.275)	(0.337)	(0.347)	(0.319)
Sample size	16791	16074	15352	14628
Panel C: four year institutions				
Log total spending	0.259	0.325	0.459*	0.451*
	(0.190)	(0.226)	(0.234)	(0.254)
Log tuition	0.123	0.189	0.252	0.306*
	(0.135)	(0.151)	(0.173)	(0.172)
Sample size	11317	10760	10212	9676

Notes : This table reports two-stage least squares estimates of the effects of tuition and spending on the log of total certificates and degrees awarded. In the first stage we regress each institution's yearly change in log total spending and log tuition on the change in the budget shock instrument (the share of each institution's revenue from state appropriations in 1990 times yearly state appropriations per capita), the change in an indicator for whether a tuition cap is in place in the current state and year, and the change in the maximum percentage increase allowed under the cap (set to zero when no cap is in place). The second stage regresses each institution's yearly change in certificates or degrees on the changes in tuition and spending from the first stage. Panel A reports results for all institutions, while Panels B and C show results for two-year and four-year institutions respectively. Both stages also control for time-varying county demographic and economic covariates, time-invariant institution characteristics such as sector, selectivity and highest degree offered, year fixed effects, and state fixed effects. Standard errors, clustered at the institution level, are in parentheses.

*significant at 10-percent; **significant at 5-percent; ***significant at 1-percent

Table A11 - 2SLS estimates of effects on freshman and upperclassman enrollment

	Current year	T+1	T+2	T+3
Panel A: log FTE freshmen				
Log total spending	0.580*	0.032	1.276***	0.829**
	(0.349)	(0.391)	(0.480)	(0.421)
Log tuition	0.148	-0.206	0.713**	0.414
	(0.194)	(0.197)	(0.281)	(0.253)
Sample size	27311	26093	24841	23610
Panel B: log FTE upperclassmen				
Log total spending	1.298**	0.356	-0.299	1.676***
	(0.589)	(0.474)	(0.464)	(0.522)
Log tuition	0.836**	-0.231	-0.054	0.406
	(0.373)	(0.272)	(0.272)	(0.302)
Sample size	27896	26646	25364	24107

Notes : This table reports two-stage least squares estimates of the effects of tuition and spending on enrollment for freshman and upperclassmen. In the first stage we regress each institution's yearly change in log total spending and log tuition on the change in the budget shock instrument (the share of each institution's revenue from state appropriations in 1990 times yearly state appropriations per capita), the change in an indicator for whether a tuition cap is in place in the current state and year, and the change in the maximum percentage increase allowed under the cap (set to zero when no cap is in place). The second stage regresses each institution's yearly change in certificates or degrees on the changes in tuition and spending from the first stage. Panel A reports results for full-time equivalent freshmen, and Panel B reports results for upperclassmen (with part-time students counting as 0.5 in both cases). Both stages also control for time-varying county demographic and economic covariates, time-invariant institution characteristics such as sector, selectivity and highest degree offered, year fixed effects, and state fixed effects. Standard errors, clustered at the institution level, are in parentheses.

*significant at 10-percent; **significant at 5-percent; ***significant at 1-percent