

A Passage to America: University Funding and International Students*

John Bound
University of Michigan & NBER

Breno Braga
Urban Institute

Gaurav Khanna
University of Michigan

Sarah Turner
University of Virginia & NBER

Abstract: Substantial subsidies to public higher education in the United States have historically allowed in-state students at public colleges and universities to pay markedly lower tuition and fee levels than counterparts who are not state residents. Yet, state appropriations for higher education have declined markedly in recent years. For university leaders facing declines in funding, potential margins for adjustment include raising revenues through increases in tuition levels, reducing resources per student (and potentially quality) by cutting expenditures, or changing the mix of students admitted to include more students paying non-resident tuition. At the same time, with strong economic growth in countries like China and India in recent decades, the pool of students from abroad academically prepared for U.S. colleges and able to pay the tuition charges has increased markedly in the last decade. In this paper, we examine whether “funding shocks” in state appropriations have led public universities to attract more foreign students who are able to pay the full fare tuition. For the period between 1996 and 2012, we estimate that a 10% reduction in state appropriations is associated with an increase in foreign enrollment of 6.2% at public research universities and about 6.7% at the resource-intensive AAU public universities. Our results tell a compelling story about the link between changes in state funding and foreign enrollment in recent years.

* We thank the Alfred P Sloan Foundation for generous research support. Breno Braga also gratefully acknowledges additional support from the Fleishman Fund at the Urban Institute. We are grateful to Richard Murphy, Jeff Smith and participants at the CESifo conference on the economics of education for helpful comments.

Public higher education in the United States has long been characterized by substantial subsidies from state governments. In exchange for these subsidies, in-state students at public colleges and universities pay markedly lower tuition and fee levels than counterparts who are not student residents.¹ Yet, state appropriations or subsidies have not only broadly decreased in the share of the costs of higher education in recent decades, but there have been marked real declines in recent years, which have been acute in those states facing the largest recessionary shocks. Between the 2007-08 academic year and the 2011-12 academic year, state appropriations for higher education fell from \$90.5 billion to \$74.4 billion (in 2013 constant dollars). For university leaders facing declines in funding, potential margins for adjustment include raising revenues through increases in tuition, reducing resources per student (and potentially quality) by cutting expenditures, or changing the mix of students admitted to include more students paying out-of-state tuition. How a public university can adjust along these margins is limited by market supply conditions from different types of students, as well as political constraints aiming to keep in-state tuition low or mandate representation of students from in-state.

Public universities value out-of-state students, including U.S. residents from other states and foreign students, for at least two reasons. First, out-of-state students face higher tuition charges for enrollment than their in-state peers, generating revenues for instructional expenditures for all students. Secondly, drawing from out-of-state may increase the pool of very high ability peers, which is also an input to the university production function (Winston and Zimmerman, 2004; Rothschild and White, 1995). An optimizing public university would aim to draw out-of-state students to the point where marginal benefits are equated with marginal costs and constraints.

¹ A long literature in public finance, dating to the late 1960s, explored the efficiency of these subsidies and the extent to which they addressed objectives of equity thought to be fostered by low tuition levels.

The number of students from out-of-state choosing to attend a public university is determined by capacity to pay, admission or academic qualification, and the expected net returns to a student's best alternative option which might be a private institution or a public university in a student's state or country of residence. For 2014-15, the average tuition and fees at a private, nonprofit university were \$31,231 compared to tuition-charged to an out-of-state student at a public university were \$22,958, while in-state students faced would face average tuition charges of \$9,139 (*Trends in College Pricing*, 2014, Table 1A). To varying degrees, some public universities have a long tradition of drawing on supply from U.S. residents from other states who find top flagship universities a "good value" relative to the private colleges and universities that may be available to them. Indeed, the University of Michigan and the University of Virginia have enrolled more than 30% of their students from out of state for more than a decade. However, not all public universities have traditionally drawn large numbers of students from out-of-state. With robust support from state appropriations and substantial numbers of well-qualified in-state students, highly-ranked institutions like UC-Berkeley enrolled few students from out-of-state until relatively recently, while other public institutions attracted few domestic out-of-state students because "home state" university options were of lower price and at least as strong in quality.

The increasing number of foreign students seeking to enroll in U.S. colleges and universities at the undergraduate level in the past decade has broadened the pool of potential students from out-of-state at public universities to include those from abroad. Overall, foreign undergraduate enrollment increased from 288,161 in fall 2000 to 482,203 in 2013, while foreign undergraduate enrollment increased from 197,133 to 331,038 at public universities.² Factors that

² Authors' tabulations from the Integrated Postsecondary Education Data System (IPEDS) conducted by the Department of Education's National Center for Education Statistics (NCES).

explain the expansion on undergraduate enrollment of foreign students include the increasing in secondary educational attainment in developing countries. Another important aspect is the rapid increase of income of the wealthier families from emerging economies. In turn, home country post-secondary options and labor market opportunities also affect the potential flow of students from abroad. Students with a constrained availability of high quality post-secondary options and those who desire to find employment in the U.S. will find U.S. higher education particularly attractive.

The broad hypothesis presented in this paper is that “funding shocks” or cuts in state appropriations have led public universities to change the composition of matriculating students, by attracting more students who are able to pay full-tuition. These public institutions have disproportionately attracted foreign students in recent years as a reflection of their relatively plentiful supply. Notably this result need not imply displacement of in-state students, and all students gain from additional resources per student. Our results focus on the link between state-level appropriations shocks and the flow of foreign students to public universities. Our identification assumption is that after controlling for institution and year fixed effects, as well as the size of a state’s college age population, state appropriations are exogenous to other factors that affect foreign enrollment of public universities.³

Using university-level data on state appropriations, enrollments, tuition rates and revenues, residency, financial aid, SAT/ACT scores and expenditures, we show that decreases in state appropriations have a striking and positive impact on foreign undergraduate enrollment in the recent period. The effect of appropriations changes on enrollment from abroad is appreciably larger than the effect on out-of-state enrollment, which is consistent with the

³ As we discuss later, this assumption is consistent with the literature which describes the cyclicity of federal programs with state level matching features (e.g Medicaid) and the political affiliation of the governor and the majority of the state legislators as the main drivers of state appropriations.

interpretation that the pool of qualified students with the capacity to pay non-resident tuition levels from abroad is much larger than the pool of domestic students. We estimate that a 10% reduction in state appropriations is associated with an increase in foreign enrollment of 6.2% at research public universities; in turn, increases in the enrollment of foreign students generate substantial gains in university tuition revenues which partially offset the loss in state appropriations. Notably, changes in state appropriations have no effect on in-state enrollment and the absence of a link between foreign enrollment and in-state enrollment suggests no crowd out at these institutions.

Overall, the rapid increase in foreign enrollment at public universities in the U.S. can be explained by the coincidence of two forces. First, the supply of foreign students seeking a U.S. college degree increased markedly. Growth in secondary educational attainment and increasing family income in China has expanded the pool of foreign applicants to American universities considerably. Second, appropriations from state governments to public universities have decreased markedly. As a result, foreign students, who pay out of state tuition and are less likely to receive need-based financial aid, became an attractive source of revenue for these institutions. In fact, our results suggest that foreign enrollment was an important source of revenue that buffered expenditure cuts at a number of public universities.

In summary, with the expansion in the pool of potential tuition-paying foreign students from abroad, public universities adjusted to declines in state appropriations by increasing enrollment on this margin. Indeed, revenue flows from these students may substantially offset the loss in state appropriations resulting in potential benefits for in-state students.

The first section of the analysis provides a backdrop, outlining the structure of public higher education in the context the U.S. market, the historical patterns of foreign student

enrollment, and the broad economic and demographic factors changing the potential pool of students from abroad. Section two provides the theoretical context with a model that considers university resource choice and selection of students, leading to key comparative statics. Section three presents the data sources and outlines the empirical strategy. Section four presents the results and the final section concludes.

Section 1. Institutional Context and Empirical Motivation

U.S. Public Higher Education

Public universities in the U.S. are unique institutions distinguished by scale, scope and funding structure (Goldin and Katz, 1999).⁴ About 63% of undergraduate degrees are awarded by public universities, even as private colleges and universities are numerically more prevalent – among institutions granting bachelor’s degrees, nearly twice as many are private non-profits (1303) as public colleges and universities (645).⁵ Public universities provide services to a range of constituencies including undergraduate students, graduate students, professional students and research serving both general purposes and the interests of local industries. Organized and governed at the state level, public universities have a vested interest in providing collegiate opportunities to in-state students, which is often manifested in below cost tuition and preferential treatment in admissions.

Public colleges and universities in the U.S. are often stratified within states in terms of resources and the extent to which they compete in national (or international markets) for students

⁴ Scale economies produce “barriers to entry,” making it difficult if not impossible to enter. Goldin and Katz (1999, 2008) argue that the modern research university largely took shape at the beginning of the 20th century as existing schools expanded their scale in terms of increased enrollment as well as their scope in terms of the breadth of disciplines covered.

⁵ See *Digest of Education Statistics* “Table 318.50. Degrees conferred by postsecondary institutions, by control of institution, level of degree, and field of study: 2011-12” and “Table 318.60. Number of postsecondary institutions conferring degrees, by control of institution, level of degree, and field of study: 2011-12”

and faculty. Typically, each state has at least one institution – often called the “flagship” – that is relatively research active and selective in its student body and has greater levels of resources per student than other institutions in the states. While not strictly hierarchical, there is nonetheless stratification among institutions within each state. Indeed, the stratification of public colleges and universities might be thought to be theoretically desirable and part of an intentional design, as in the case of the California Master Plan.⁶

Some public universities compete in the national market and draw students from many states, while others compete in regional markets, and others draw their students nearly entirely from localities. As one indicator, there are five public universities typically ranked among the top-30 undergraduate colleges and universities in the country.⁷ While institutional resources are one determinant of whether a public university draws students from out-of-state, there is considerable heterogeneity in the extent to which research universities draw domestic students from other students. At one extreme, out-of-state domestic students are less than 5% of domestic enrollment at institutions like University of California-Davis, University of California-Irvine and Texas A & M; in contrast, institutions like the University of Michigan-Ann Arbor, University of Colorado Boulder, University of Oregon and the University of Iowa draw more than 35% of domestic students from other states (Table 1).

The capacity of public universities to compete in a national (or international) market for undergraduate students is also driven by price. Highly-ranked public institutions charge

⁶ Sallee, Courant and Resch (2008) model the optimal allocation of resources across students and, when they assume complementarity between student ability and college resources, then efficient allocation will match well-prepared students with highly-resourced schools. Associated empirical work shows that stratification is somewhat greater in larger states.

⁷ University of California Berkeley, UCLA, University of Michigan-Ann Arbor, University of Virginia and University of North Carolina-Chapel Hill.

somewhat lower tuition than the “sticker price” charged by their peers in the private sector.

Some examples illustrate for 2014-15 tuition and fees:

<u>Public Out-of-State</u>		<u>Private University</u>	
UC-Berkeley	\$35,852	Georgetown	\$46,744
University of Michigan	\$41,906	Johns Hopkins	\$47,060
UCLA	\$35,583	Northwestern	\$47,251
University of Virginia	\$42,394	Vanderbilt	\$43,838

Funding U.S. Public Higher Education

The primary sources of funds for instructional expenditures at public universities are appropriations from state governments and tuition revenues, with more modest resources from private philanthropic sources. The balance between state appropriations and tuition revenues has shifted markedly over time toward greater reliance on tuition revenues. While this shift began in the 1990s, it accelerated with the Great Recession in 2008. Figure 1 shows appropriations per full-time equivalent (FTE) student at public colleges and universities along instructional expenditures per FTE student over the last 30 years.⁸ Over this interval costs rose steadily through the 1980s and 1990s, reflecting in part the overall increase in the wages of skilled labor and the limited capacity of colleges and universities to increase productivity by substituting capital for labor. Overall, constant dollar costs per FTE at public colleges and universities rose from about \$6000 in 1983-84 to about \$8200 in 2000-01, and average expenditures have been largely stagnant for the last decade. Concurrently, appropriations per student from state governments from the state governments declined broad, secular decline with clear downward cycles following recessions in 1991, 2001, and 2008. Overall, appropriations per student have fallen from a peak of \$10,138 in 1986-87 to about \$6,800 in 2012-13. The combination of the

⁸ Note that instructional expenditures do not include the costs of academic administration or student services. Representing appropriations relative to total expenditures for research universities is misleading because the overall budgets for these institutions include hospitals which are ancillary to undergraduate instruction.

increasing commitment of state budgets to matching federal programs and the rising volatility of tax revenues in the last two decades likely constrain states' capacity to fund higher education, particularly during cyclical downturns. Kane, Orszag and Apostolov (2005) show how state matching incentives for federal programs like Medicaid may "crowd out" funding of higher education as the former are entitlement programs, while cyclical contractions are exacerbated by this shift as revenue shortfalls must be absorbed in the smaller discretionary share of state budgets. What is more, tax revenue volatility has increased since 2000 (Seegert, 2015), largely as a function of increased reliance on sales and income taxes.

A result of the declining support from the state is increased pressure on public colleges and universities to raise resources to cover expenditures from tuition charges. Public 2-year and 4-year in-state tuition changes are shown in Figure 2A, in relation to changes in private charges. Of particular note, in-state public charges have risen at a much greater rate in recent years than tuition levels at private institutions. Indeed, states with the most severe economic downturns in the most recent recession were among those who raised tuition the most, with in-state tuition changes greatest at the flagship and more selective institutions within each state where the correlation between flagship tuition charges and the state unemployment rate about 0.54 (see Figure 2B and Barr and Turner (2012)). Yet, while lawmakers acknowledged some need for tuition increases in the wake of steep appropriations cuts in the recession, there is strong political pressure to limit the rate of growth in public in-state tuition.⁹ Public universities have also increased out-of-state tuition levels markedly in recent years (about 12% in real terms from 2009

⁹ Recent examples include Wisconsin (<http://www.jsonline.com/news/statepolitics/scott-walker-moves-to-limit-future-uw-tuition-increases-to-inflation-b99480643z1-299613051.html>), Florida (<http://www.palmbeachpost.com/news/news/state-regional-govt-politics/bills-to-limit-universities-ability-to-increase-tu/nfDCF/>), and Oregon (<http://www.katu.com/politics/Oregon-universities-pledge-tuition-limits-if-lawmakers-hike-funding-305785451.html>)

to 2014, College Board (2014)), though the market imposes limits on the increases as out-of-state students are likely to be quite price elastic.

Beyond increasing the tuition price charged to students, public universities may increase revenues by changing the composition of students toward those that are able to pay the out-of-state rate. That a number of states have purposefully sought to increase representation of students paying out-of-state tuition has been documented by a number of higher education analysts. For example, a *New York Times* article (Lewin, 2011) notes that “more than half of the admissions officers at public research universities ... said that they had been working harder in the past year to recruit students who need no financial aid and can pay full price.” One story in the *Chronicle of Higher Education* (Hoover and Keller, 2011) describes an “out-of-state goldrush” with admissions officers at public universities increasingly “hustling for business” to find new markets.

Yet, higher education policy experts have recognized that the “supply” of well-qualified domestic out-of-state students is not elastic. Indeed, public universities – like their private counterparts – have found that adding students from out-of-state may come with “costs” in terms of tuition discounts – either merit aid or need-based financial aid, while adding additional students from out-of-state may come with a sacrifice in student qualifications.¹⁰

The supply of well-qualified students from abroad is relatively more elastic, and has become increasingly so as incomes in emerging economies have risen. This allows universities to use foreign enrollment as an important tool in recovering lost state appropriations.

¹⁰ Quoted in the *Chronicle of Higher Education*, Indiana University Professor Don Hossler notes: “There cannot possibly be enough students with the means and a willingness to travel out-of-state for all the schools that want to tap this market. Institutions seeking to offset enrollment and/or revenue declines with out-of-state students are going to find it a tough road. And to the extent they are successful, they are likely to increasingly find that they have to get into a cycle of ever increasing the dollar value of financial aid awards to achieve their goals” (Hoover and Keller, 2011).

Supply of Students to U.S. Public Universities

In-State Students

States differ markedly in trends in the number of high school graduates and potential college-age students. Over the long horizon of the last half-century, there have been dramatic differences in the changes in the number of 18-year olds by state. Indeed, some states have experienced declines while other states have experienced substantial increases in the college-age population. To illustrate, states like Iowa (-22%), Indiana (-13%), Ohio (-18%), and Michigan (-15%) experienced declines in their college-age populations from 1970 to 2004, while states like Florida (+99%), Texas (+56%), California (+42%) and Georgia (+41%) experienced growth in college-age population over this interval.¹¹

For states that have experienced actual declines in the number of potential students over time, there are particularly strong incentives to draw students – either domestic or foreign – from out-of-state as they will likely have “excess capacity” in dorms and class offerings. These capacity issues are likely to be particularly relevant at those institutions in which a large fraction of the undergraduate student body is residential and a substantial fraction of the faculty is tenured or tenure track. On the other hand, states like Texas and California that have experienced large-scale population growth since the middle of the 20th century (when many large-scale investments in public higher education were made) are less likely to attract out-of-state students.

Domestic Out-of-State Students

One factor affecting public institution’s capacity to draw students is academic quality. Those state public universities that compete with the best private universities draw many

¹¹ Data reflect the population age 18 as reported by the Census.

students from out-of-state. Note however, that the UCLA and the University of California at Berkeley have been exceptions to this norm until recently. A second factor is the extent to which public universities provide “amenities” that are demanded by students such as sunshine or snow-skiing (Jacob, McCall and Stange, 2013).

By revealed preference, domestic students who attend out-of-state public universities prefer these institutions to their best in-state option, even as price differs. Because out-of-state tuition exceeds in-state options and few public universities meet financial need with grant funding, it follows that domestic out-of-state students are relatively affluent. It also follows that these students are likely to be relatively high achieving. The U.S. born students particularly likely to attend public out-of-state public institutions tend to be from the northeast or states with a limited supply of selective public options (Bound, Hershbein and Long 2009); not surprisingly, New York is the largest “feeder” state for both the University of Virginia and the University of Michigan.

Foreign Students

Overall, the number of foreign students in the United States has increased markedly in recent decades, with undergraduate enrollment rising 68% from 288,000 in 1990 to 483,000 in 2013 and graduate enrollment increasing 32% from 240,700 to 356,900 over the same period.¹² Foreign undergraduates represent a relatively small share of undergraduate enrollment (3.3% in our sample of 4-year public and private non-profit institutions), and are a much larger share of enrollment in doctoral programs. For example, 29% of all doctorate degrees and 34% of science and engineering doctorate degrees awarded in 2011 went to temporary visa holders. Over the three decades since 1980, the average annual growth rate in foreign graduate enrollment has been

¹² *Digest of Education Statistics*, “Table 306.10. Total fall enrollment in degree-granting postsecondary institutions, by level of enrollment, sex, attendance status, and race/ethnicity of student: Selected years, 1976 through 2013” https://nces.ed.gov/programs/digest/d14/tables/dt14_306.10.asp?current=yes

somewhat greater at 1.9% per year than undergraduate enrollment, though since 2005 undergraduate enrollment has grown at annual pace of 4.6% compared to 2.5% for graduate enrollment. Still, in the period since the collapse of the financial markets in 2008, enrollment of foreign students in U.S. higher education has continued on an upward trajectory, rising 14.6% in the 2008-11 interval among undergraduates and 6% among graduate students.

The supply of students from abroad to U.S. higher education institutions is a function of home country education markets and labor markets. We emphasize four broad factors affecting supply from abroad: the number of students completing secondary education and “prepared” for post-secondary study, the extent to which home countries are “supply constrained” in the availability of comparable quality higher education, the number of students who can afford the cost of pursuing a college degree abroad, and the extent to which study in the U.S. provides an “option value” to the U.S. labor market which in circumstances where U.S. employment opportunities dominate those abroad.¹³

Capacity to pay for higher education is a factor which notably limits the flow of students to the U.S. at the undergraduate level. Unlike the doctorate level where it is common for talented students to receive full support in the form of fellowship, teaching and research support, foreign undergraduates are generally expected to make full tuition payments. For this reasons, trends in the flow of students at the undergraduate and graduate levels tend to differ quite markedly by

¹³ A few papers explore motivations for foreign students coming to study in the United States. Rosenzweig (2006) proposes two models for foreign student mobility: a “constrained domestic schooling model”, which leads to the hypothesis that foreign students seek education in the U.S. due to a dearth of home country options; and a “migration model”, which points to the hypothesis that foreign students enroll in the U.S. to increase the probability that they will find employment in the U.S. when they graduate. Using a cross-section of data, he finds that the number of foreign students is positively related to the number of universities in a home country, and negatively related to the home country “skill-price”, the market wage for a given skill level. Rosenzweig concludes that the migration model is the correct model, meaning foreign students come to the U.S. for education for an option value to enter the U.S. labor market. Bound, Demirci, Khanna and Turner (2014) analyze the importance of the ‘migration model’ for the flow of foreign workers in IT. However, Hwang (2009) uses a panel of data from an alternate source, and finds a positive relationship between a home country’s skill-price and enrollment in the U.S.

country of origin. For some countries that are working up the development trajectory, such as China and India, the growth in graduate education precedes growth in undergraduate education likely because U.S. institutions are able to offer substantial financial aid for graduate study, particularly in PhD science programs.¹⁴

Countries from which there has been dramatic growth in undergraduate enrollment in recent years include China, Saudi Arabia, India and South Korea as shown in Figure 3. In academic year 2013-14, these four countries accounted for more than 50% of undergraduate enrollment of foreign students. China alone is particularly noteworthy: with 110,550 (30%) of the 370,724 undergraduate students enrolled in 2013-14, the expansion in enrollment of undergraduate students from China from just 8034 students in 2003-04 accounts for 90% of the increase in foreign undergraduate over this decade.¹⁵ Few in the Chinese population could finance undergraduate education in the U.S. until China began to experience rapid economic growth in the late 1990s.

Two notable changes in China in the last decade have fueled the dramatic expansion in the overall demand for college education, as well as the flow of students to the U.S. First, there was a dramatic increase in participation in secondary education. The number of students graduating from a non-vocational secondary institution in China rose from around 3 million in the year 2000 to more 8 million in the year 2013 (China Statistical Year Book, 2013). Secondly, there was a dramatic rise in GDP with per capita income increasing from \$2,864 in 2000 to

¹⁴ For affluent western economies with well-developed home country education systems such as Germany and Canada, undergraduate and graduate enrollment are near the same scale and exhibit modest variation over our period of analysis.

¹⁵ Saudi Arabia is the second country with substantial growth over this decade at the undergraduate level: from 2022 students to 26,865. The introduction of an explicit government fellowship for study abroad is clearly a contributing factor to the observed increase in enrollments (Kurtz, 2012). Motivated by a desire to reduce hostility in the Saudi public toward the United States after 9/11, the Saudi government began the King Abdullah Scholarship program in 2005, which has continued to expand. (<http://www.mohe.gov.sa/en/studyaboard/king-abdullahstages/pages/default.aspx>).

\$11,904 in 2012, a more than 4-fold increase. Figure 4 shows that close alignment of changes in capacity to pay with the change in the percentage of Chinese youth (ages 18-24) studying abroad. We calculate that while less than 0.005% of Chinese families could afford tuition, room and board from a U.S. public university in the year 2000, by 2009 (the last point shown on the graph) approximately 0.032% would have been able to afford payment and growth continues exponentially as by 2013 more than 2% families are predicted to have the capacity to pay.¹⁶ Notably the fraction of those predicted to be able to afford study abroad who are enrolled at a U.S. university actually declines over this interval. While some of the students from China studying in the U.S. are from the extreme right tail of the income distribution (Liu, 2015; Higgins, 2013; Fischer, 2014), other Chinese students have parents who invest a disproportionate share of income in the education of a child, where the “one-child” policy in effect in many parts of China leaves many parents in this generation with a single child.

While there is no question that post-secondary options have increased in China and other Asian countries, expansion in the number of places for enrollment has been most limited among their top-tier universities. Indeed, the “selectivity” – measured by applicants relative to admissions opportunities – to top schools in India and China is yet greater than that experienced by the most elite private universities in the U.S. As a result, higher education supply constraints abroad push students to consider enrollment in the U.S. as well as other countries like the U.K. and Australia with well-developed higher education sectors. Many students from abroad are not

¹⁶ Authors’ calculations, based on income distribution data from the World Bank and Average Tuition Out-of-State Student in a Public University + Room and Board from IPEDs.

offered admission at the most resource-intensive institutions in their home countries like Tsinghua in China and choose to consider alternatives in the U.S.¹⁷

One factor which may change the “calculus” of students choosing between an out-of-state public and a private university is eligibility for financial aid. No public universities offer need-based aid for international students and only a few private institutions offer such aid,¹⁸ though at most schools offering aid based on academic merit, foreign students are eligible potentially resulting in a “net price” well below the “sticker price.” For domestic students, the relative affordability of public out-of-state institutions and private institutions differs by family income and achievement.¹⁹

Two broad points about the public universities in the U.S. motivate our theoretical and empirical analysis. First, declines in state appropriations and the particularly sharp recessionary contractions in some states likely push optimizing public universities to seek out additional sources of revenue from students who can pay the higher out-of-state tuition rates. Secondly, while per capita incomes have been stagnant and the number of high school graduates increasing only modestly in the U.S., potential flows of students to the U.S. from abroad have increased markedly.

Section 2. Theoretical Framework

¹⁷ A recent *New York Times* article describes how even the most qualified students in India are being crowded out of top Indian colleges (Najar, 2011). China’s admission process, which relies solely on scores from the *gao kao* exam, is a highly competitive and stressful ordeal for students and parents which results in only 3 in 5 students being admitted to any Chinese college (LaFraniere, 2009).

¹⁸ One list includes: MIT, Harvard, Princeton, Yale, Dartmouth and Amherst.
http://www.internationalstudent.com/schools_awarding_aid/

¹⁹ There is some evidence (Turner, 2013) that public universities tend to limit grant-based aid to very low-income students, while a number of elite private universities offer grant aid to students at higher income levels. Universities in both sectors often engage in “tuition discounting” (or price discrimination to attract students) with merit aid or institutional grants.

To answer the question of whether “funding shocks” in state appropriations have led public universities to change the composition of admitted students, attracting more foreign students who are able to pay full-tuition in response to funding declines, we develop a theoretical framework that describes a public university’s behavior.

In the model, the objective of a public university is to provide high quality education to the highest number of in-state students. Public universities take state appropriations and tuition prices as given, and their optimization involves choosing spending per student and the combination of in-state, out-of-state and foreign students to admit. In turn, collegiate quality depends on resources spent and the overall inherent quality of the student body. The model predicts that public universities enroll foreign students to the extent that they pay higher tuition and thus cross-subsidize the education of in-state students, while maintain the university’s academic standards. Another prediction of the model is that when state appropriations decline, public universities are more likely to admit foreigners because the marginal benefit of adding foreign students (and associated tuition revenues) increases.

Our model builds on work by Epple, Romano, and Seig (2006) and Epple, Romano, Sarpça and Seig (2013) who present a general equilibrium model of the market for undergraduate higher education which provides predictions about the distribution of students across colleges by ability and capacity to pay. Unlike their work, we present a partial equilibrium model where public universities can recruit foreign students while treating the supply of applicants as given.

2.1 Model Framework

In this partial equilibrium analysis we model the behavior of a typical public university. The university takes the supply of applicants and tuition prices as given and we model its enrollment decisions and its investments in education.

University's objective function

The public university has a mandate to provide high quality education to the highest number of in-state students. We define the university's objective function as:

$$g(K_s, q),$$

where K_s is the number of in-state students enrolled and q is the quality of education provided by the public university. We assume that $g(\cdot)$ is a twice differentiable, and an increasing function in both arguments, indicating that the university desires to increase both the enrollment of in-state students as well as the quality of the education they provide.

As in Epple, Romano, and Seig (2006), the quality of the education is:

$$q = q(\theta, I),$$

where θ is a student body quality measure, which can be defined as the mean ability level of the student body, and I is the total resource investment made by a university in education. The function $q(\cdot)$ is also twice differentiable, and increasing in both arguments.

Student ability

We assume that a university faces a given supply of applicants that are heterogeneous in terms of their ability.²⁰ As a college makes its admissions decisions (which translate to enrollment), it takes into consideration how the ability of the marginal applicant to enroll will affect the quality of its student body. We define the marginal change in the student body quality associated with increases in enrollment of student of type j :

²⁰ Unlike Epple, Romano, and Seig (2006), we do not model the college decisions of students.

$$\theta_j = \frac{\partial \theta}{\partial K_j} \text{ for } j=s,o,f,$$

where K_s , K_o , K_f are the number of the in-state student, out-of-state and foreign enrolled respectively. This function reflects the quality of the marginal student that a university can recruit from in-state, out-of-state and abroad. The university will take θ_j into consideration when deciding who to enroll.

University Cost Function

The cost function for each university is given by

$$C(K_s, K_o, K_f, I) = \varphi(K_s, K_o, K_f) + \frac{\rho}{2} I^2,$$

where K_s , K_o , K_f are the enrollment levels for in-state, out-of-state and foreign students respectively. We assume that the function $\varphi(\cdot)$ is a strictly increasing and convex function in all arguments. This function represents costs associated with expanding enrollment, such as office-hours time for instructors, administrative staff, etc. We define the marginal costs associated with increase in K_j :

$$\varphi_j = \frac{\partial \varphi}{\partial K_j} \text{ for } j=s,o,f$$

The university also faces a convex cost function for the investment in education. This represents costs that affect quality of education provided to students, such as new computer labs, research facilities, etc. This increasing marginal cost of investment prevents universities from spending all its resources in investment.

University Revenue Function

The university's revenue is given by:

$$R(K_s, K_o, K_f) = R + p_s K_s + p_o (K_o + K_f),$$

where R denotes the non-tuition income of the public university. In our framework, it corresponds mainly to state appropriations, but could also include endowment revenues. The in-state tuition is given by p_s and the out-of-state tuition by p_o , which is paid by both foreign and out-of-state students. We assume that the public university takes R , p_s and p_o as given when making their admission and investment decisions.

2.2 The Optimization Problem of a Public University

The public university chooses the number of in-state, out-of-state and foreign students to enroll and, correspondingly, how much to invest in education in order to maximize its objective function. The choices must satisfy a budget constraint and non-negativity of its inputs. The university problem is defined as:

$$\max_{I, K_s, K_o, K_f} g(K_s, q(I, \theta))$$

Subject to the budget constraint:

$$R + p_s K_s + p_o K_o + p_o K_f = \varphi(K_s, K_o, K_f) + \frac{\rho}{2} I^2$$

And non-negative constraints

$$K_s, K_o, K_f, I \geq 0$$

Based on the set-up above, we can rewrite the university's behavior as a system of equations defined by the first order conditions (FOC):

a) FOC with respect to in-state students

$$\frac{g_s}{\lambda} + p_s = \varphi_s - \frac{g_\theta \theta_s}{\lambda}$$

b) FOC with respect to out-of-state students:

$$p_o = \varphi_o - \frac{g_\theta \theta_o}{\lambda}$$

c) FOC with respect to foreign students:

$$p_o = \varphi_f - \frac{g_\theta \theta_f}{\lambda}$$

a) FOC with respect to investment in education:

$$\frac{g_I}{\lambda} = \rho I$$

where g_s , g_θ , and g_I are the first derivative of the function $g(\cdot)$ with respect to K_s , θ and I respectively, and λ is the Lagrangian multiplier of the budget constraint.

The FOC provide some intuition regarding the decision of the public university. In all equations, the left hand side represents the marginal benefit of increasing the input and the right hand side represents the marginal cost of increasing the input.

- *In-state students*: The marginal benefit of an in-state student is given by the tuition they pay as well as the monetized benefit of the increase in an in-state student's attendance. As discussed before, public universities have the mandate to provide high quality education to the highest number of in-state students. The marginal cost is the cost of enrolling an additional in-state student as well as the (potential) decrease in the quality of the current student body by expanding the enrollment of in-state students.
- *Out-of-state and foreign students*: The marginal benefit of foreign and out-of-state students is the tuition they pay, which is higher than the tuition paid by in-state students. The marginal cost is the expenses associated with their enrollment as well as the monetized cost of the (potential) decrease in the quality of the current student body associated with the expansion of enrollment of out-of-state and foreign students.

- *Resource Investment*: The marginal benefit is the monetized benefit of an increase in the quality of education provide by the university. The marginal cost is the expenses associated with the investment.

Overall, a public university enrolls in-state, out-of-state and foreign student until their marginal benefit is equal to their marginal cost. As a result, the relative tuition, marginal costs and quality of the marginal applicant between in-state, out-of-state and foreign students will determine the share of each type of student that will be enrolled.

2.3 Parametric Assumptions and the Relationship with State Appropriations

In order to derive the relationship between state appropriations, enrollment and investment, we make some parametric assumptions. This exercise will illustrate that the model can predict some of the empirical findings of the paper under some extra assumptions.

Objective Function

We first assume that investment and mean ability of the university are perfect substitutes:

$$q = \alpha I + \theta$$

In order to provide quality education, the university can perfectly substitute a lower quality student body with more investments in education.

We also model the objective function of the university as quasi-linear in the quality of the education:

$$g(K_s, q(I, \theta)) = (1 - \gamma) \ln K_s + \gamma(\alpha I + \theta),$$

where γ is the weight assigned to the quality of education and $1-\gamma$ is the weight assigned to the enrollment of in-state students.

As it will be clear later, the quasi-linear functional form assumption guarantees that only foreign enrollment is affected by changes in the state appropriations, which is an empirical finding of the paper. This assumption assures that there is “no income effect” for in-state enrollment, as universities will only adjust foreign enrollment as a response to changes in state appropriations.

Ability of Applicants

We assume that the marginal change in the student body ability associated with the expansion of enrollment is negative for each j , such that:

$$\theta_j < 0 \text{ for any } j=s,o,f$$

As a university expands the enrollment of any type of student, it necessarily decreases the quality of its student body. In other words, any marginal applicant willing to enroll is worse than the average student of the university. This assumption is consistent with a university ranking their students by their ability and admitting first the highest ability applicants.²¹

In addition, we assume the θ_f does not change with K_f . This assumption is consistent with an inelastic supply of foreigners, which implies that the ability of the marginal foreign student changes very little as the university expands foreign enrollment.

²¹ Note, however, that some universities might have a marginal foreign (or out-of-state) applicant that is better than its average student body. In this situation, increasing foreign enrollment could be a strategy for the university to improve education quality through its peer effects. As we focus on financial aspects of foreign enrollment in this paper, we will ignore such situations.

Finally, we assume that both θ_s and θ_o decrease with K_s and K_o respectively. As universities expand the enrollment of in-state and out-of-state students, they have access to a worse pool of applicants from each of those places:

$$\theta_j = -\mu_j K_j \text{ for } j = s, o,$$

where μ_j is a constant greater than zero.

Cost Function

We assume that the marginal cost of enrollment of a student is constant and does not depend on a student's origin, such that:

$$\varphi(K_s, K_o, K_f) = c(K_s + K_o + K_f),$$

where c is a constant greater than zero.²² This assumption is likely to hold if universities are not operating under any capacity constraints.

States that face a shrinking college-aged population, such as Michigan and Iowa, are more likely to have universities operating under capacity. They have built universities that are likely to be bigger than the needs of their population. On the other hand, universities from fast growing states, such as California and Texas, are more likely to have universities operating close to their capacity.

Net Revenue and Net Cost Generator Students

We assume that tuition price and marginal cost must satisfy the following restriction:

$$p_s - c < 0 < p_o - c$$

²² Universities might also face higher marginal costs to enroll foreign students, as they are required to provide extra paperwork for visa application, extra language training, etc. One can also claim that there are political costs associated with the enrollment of foreign students. Such modification wouldn't affect the predictions of the model and for simplicity we ignore them here.

This condition implies that foreign and out-state students are net revenue generators to the university. Their tuition revenues can pay their marginal cost as well as can be used to cross-subsidize the education of in-state students and increase investment. In-state students are net cost generators to the university. The tuition they pay is lower than their marginal cost. There is political pressure by the state to assure that college tuition is kept low for in-state students.

2.4 Solution

From the first order condition with respect to foreign students' enrollment, the value of the Lagrangian multiplier is:

$$\lambda^* = \frac{-\gamma\theta_f}{p_o - c}$$

Incorporating this Lagrangian multiplier in the first order condition with respect to investment, we derive the optimal investment decision of a university:

$$I^* = \left(\frac{p_o - c}{-\theta_f} \right) * \frac{\alpha}{\rho}$$

which is an increasing function of the net revenue generated by foreign students and out-of-state students (note that $\theta_f < 0$) and not a function of state appropriations R. In this setup, the revenue generated by foreigner students provides the resources that a university can use to invest in better education.

Using the FOC with respect to out-of-state enrollment and the marginal change in student body ability, we can demonstrate that the optimal enrollment of out-of-state students is:

$$K_o^* = \frac{-\theta_f}{\mu_o}$$

which is a negative function of the ability of the marginal foreign student recruited by the university. The intuition is that foreigners and out-of-state students generate the same (net) revenue to the university. As a result, universities will enroll out-of-state students until their ability is equal to the ability of the marginal foreign student enrolled.

In the same way, we can demonstrate that the enrollment of in-state students is implicitly defined by:

$$\frac{1 - \gamma}{K_s^*} - \gamma \mu_s K_s^* + \lambda^* (p_s - c) = 0$$

which is strictly positive for sufficient low γ . Using the implicit function theorem, one can easily show that K_s^* is positively related to the tuition paid by in-state students. This predicts that public schools are willing to enroll more in-state students if they could charge them a higher tuition. In addition, the enrollment of in-state students is also positively related to the tuition paid by foreign-students (through changes in the Lagrangian multiplier). As discussed earlier, public universities are using foreign students to generate revenues that can cross-subsidize the education of in-state students.

Note that in this set-up, the enrollment of in-state students does not vary with state appropriations. This result follows from the quasi-linear function form assumption of the objective function, which implies that there is no “income effect” on in-state student enrollment.

Finally, using the optimal investment, the in-state enrollment decision and the budget constraint, we derive an expression for the enrollment of foreign students in a non-elite university:

$$K_f^* = \frac{1}{p_o - c} \left[(c - p_s) K_s^* + \frac{\rho}{2} I^{*2} - R \right] - K_o^*$$

This expression provides some interesting insight. First, the enrollment of foreign students is negatively related to state appropriations. This result is a direct implication of the fact that foreign students are used as a source of revenue for the university to finance its operations. While the university dislikes increasing its foreign enrollment since additional foreigners decrease the quality of the student body, the university can use their revenues to increase investment and the enrollment of in-state students. If state appropriations decline, the relative benefit of a foreign student increases and foreign-students become more desirable to the university.

Second, there is no crowding out in the model. In fact, the number of foreign students is positively related to the number of in-state students. In addition to generating more revenues for the university which cross-subsidizes the education of in-state students, in our model the marginal cost of enrolling an in-state student does not change with an increase in foreign enrollment. Note however, that this assumption is likely to hold only if the university does not face any capacity constraint, what is suggested by some of our empirical findings.

Finally, there is a negative association between the enrollment of foreign students and out-of-state students. This is not surprising given that in the model they both serve the same purpose: cross-subsidize the education of in-state students. Ultimately, the share of out-of-state and foreign students will depend on the ability of the marginal applicant that the university has access to from each type.

Section 3. Empirical Strategy and Data Sources

Our model offers a number of broad predictions which we assess in an empirical context using annual data on university enrollment by residency, state appropriations, tuition levels,

institutional expenditures and other state-specific factors affecting enrollment. Our aim is to assess whether the model provides a reasonable framework for understanding how public universities adjust to changes in state appropriations in terms of the students admitted and the level of resources devoted to instructional activities. Because it is beyond the scope of available data and a parsimonious model to capture the complexity of university production functions which likely vary widely in technology, outcomes, scale and so forth, our objective is not to estimate structural parameters but to measure the observed reduced-form responses to plausibly exogenous variation.

3.1 Estimation Strategy

Our regressions focus on the link between two sources of variation -- changes in state appropriations and changes in cohort size within a state – and our outcomes of interest include enrollment by residency, academic characteristics of students, and finance variables such as instructional expenditures. We use a panel of institutional observations for public universities and regress university-level measures of enrollment by residency and instructional expenditures on appropriations, cohort size and state economic conditions. Thus, the level of observation is at the level of the university (i) and the year (t). The primary specification is:

$$y_{it} = \beta_0 + \beta_1 StateAppr_{it} + X_{it}\beta + \gamma_t + \delta_i + \varepsilon_{it} ,$$

where y_{it} is the outcome of interest and γ_t and δ_i include year and institution specific fixed effects, respectively. The purpose of the year fixed effects is to focus identification on the changes to appropriations unique to the institution rather than overall secular economic changes while institution fixed effects remove baseline differences in universities linked to overall resources, research outcomes, faculty quality and so forth. The variation that helps identify our reduced-form parameters, therefore, is not driven by institutional specific characteristics nor by

year-specific shocks. The unforeseen recession affected state appropriations for some universities more than others, and we predict that those that witnessed comparatively larger falls in appropriations, made greater adjustments to their student body to recover these funds.

Since college-age populations strongly drive enrollment patterns, we control for Census estimates of the population at age 18 by state. In specifications where we may expect local economic factors to directly affect outcomes, other than via state appropriations, we control for the state-level unemployment rate. We weight the regressions by the undergraduate population while also calculating robust standard errors clustered at university level.

Based on this specification, our identification assumption is that after controlling for institution and year fixed effects as well as the size of state college aged population, state appropriations are exogenous to other factors that affect the admissions decision of public universities. While we cannot test directly our identification assumption, this is consistent with the literature that describes the determinants of state appropriation. Overall, the cyclical pressures from federal programs with state level matching features (e.g Medicaid) and the political affiliation of the governor and the majority of the state legislators are understood to be the main drivers of state appropriations (Okunade 2004 and Kane, Orszag and Apostolov, 2005).

We also estimate a number of specifications of a similar form in which foreign enrollment is the regressor of interest. While there is not a causal interpretation tied to these estimates, they provide an important reference on the association between changes in foreign enrollment and other outcomes of interest in higher education.

3.2 Data Sources

Data on enrollments, degrees conferred, and finance variables at the level of each college and university are collected annually through several sources. First, as part of a long-standing federal data collection mandate the Integrated Postsecondary Education Data System (IPEDS)

collects data in annual “modules” related to different university functions, including enrollment, finances and degrees awarded. We focus our main analytics on the period from 1996-2012 (where 1996 corresponds to the 1996-97 academic year), as this is the interval in which there is a large pool of foreign-born students available to consider undergraduate education in the U.S.

The Fall Enrollment survey records enrollment by level and visa status at the level of each post-secondary institution. The survey records enrollment by academic level, distinguishing first-time freshmen, all undergraduate students and graduate students; we focus our work on first-time freshman enrollment at the undergraduate level. The distinction between temporary visa holders and U.S. residents is central to our work and counts of “Temporary Residents” by enrollment level are recorded for each year of our analysis. By definition, those holding temporary visas are foreign-born who are “not a citizen or national of the United States and who is in this country on a visa or temporary basis and does not have the right to remain indefinitely”; thus, those born abroad who have become permanent residents or naturalized citizens before college enrollment are not included in our measures. Nearly all non-resident students at U.S. colleges and universities hold an F or “student” visa.²³

To distinguish domestic students, in terms of those who are “in-state” and those who are residents of other states we use from the American Survey of Colleges (ASC), conducted annually by the College Board. While there are many of the same data elements in this source as in the IPEDS Institutional Characteristics data collection, the ASC has more detail on the characteristics of admitted and matriculating students. For both first-time students and all

²³ F visas are further distinguished among F-1 visas for full-time students, F-2 visas for dependents of F-1 visa holders and F-3 visas for ‘border commuters’ – primarily, Mexican and Canadian students who reside in their country of origin while enrolled in the U.S. The vast majority of F 627,704 visas issued in 2014 are F-1 (595,569), with 31,732 F-2 and 403 issues in the F-3 category (Department of State, “Nonimmigrant Visas by Individual Class of Admission” <http://travel.state.gov/content/dam/visas/Statistics/AnnualReports/FY2014AnnualReport/FY14AnnualReport-TablXVIB.pdf>).

undergraduates, the ASC queries percentage of students from out-of-state excluding nonresident aliens from the numerator and denominator of the measure. These factors allow us to then distinguish counts of in-state and out-of-state students from the number of students enrolled as citizens and permanent residents.²⁴

In addition, IPEDS collects detailed financial information including revenue from different sources and expenditures, where we focus on those tied to instruction. For tuition measures, we make use of “Total Tuition Revenue” which is the accounting measure of tuition charged to students at all levels along with the measure of “Net Tuition Revenue” which is the former less financial aid provided by the institution.

In our results, we present outcomes for several categorizations of public universities. First, we define as “Public” all the 172 research universities classified in the Carnegie system as either: (1) very high research activity, (2) high research activity, (3) doctoral-granting. This definition broadly includes any doctorate granting public institution. Second, we defined as “Research” the 138 public universities which are high or very high research activity according to the same Carnegie definition, which includes public universities with substantial federal research support. Third, we focus on the 50 “Flagship” universities, producing a selection of one for each state which is generally the most selective or research intensive university in the state. An advantage of this classification is that it allows for maximal variation across states, including all fifty states. A disadvantage is that some states like Michigan and California have multiple highly-ranked institutions, often more resource intensive than the best public university in other states. The fourth categorization is to limit the analysis to the public universities that are members of the American Association of Universities (AAU), a membership organization of the

²⁴ The IPEDS panel also includes a “Residence and Migration” component which provides tallies of enrolled students by permanent address at the time of application, which are available in even-numbered years. These measures are highly correlated, though not identical to the measures we employ.

62 leading public and private universities in the U.S. and Canada. We focus on the 34 public U.S. universities that are listed in Table 1. AAU universities tend to be more selective and have higher resources than the overall universe of public research universities.

Section 4. Empirical Results

Our interest is in understanding how public universities respond to changes in state appropriations in terms of composition of enrollment, tuition revenues and expenditures. We assume that public institutions were unlikely to fully anticipate the depth of the Great Recession and its budgetary implications nor were they able to predict the local political factors that affect variation in public funding. Thus, we begin with the consideration of how within-state changes in state appropriations affect enrollment by student residency. State appropriations – and, by association, the composition of enrollment – may affect institutional revenues and expenditures through either the quantity of students paying different rates or the rates charged to different student groups. At the end of this section, we provide an accounting of the extent to which changes in state appropriations are accommodated by shifting enrollment composition and tuition charges.

4.1 Effects of State Appropriations on Enrollment

Our first empirical test is to examine the effect of variation in state appropriations on enrollment distinguished by residence in-state, out-of-state and abroad. We focus on the period between 1996 to 2012 and include institution and year fixed effects in all specifications. Table 2 shows the results for public universities distinguished by the designated “flagship,” the more limited group of AAU members, public research universities (designated as those with sizeable

federal research funding) and the broader group of public doctorate-granting universities. The distinction between foreign students and domestic students is marked.

For foreign students during this interval, we find a consistent negative relationship between appropriations and enrollment (Panel A), indicating that negative appropriations shocks are tied to increases in foreign enrollment. We estimate that a 10% reduction in state appropriations predicts an increase in foreign enrollment of 8.8% at flagship universities, 6.7% at AAU institutions, 6.2% at the public universities and 4.4% at the broader group of public universities. We take this finding as evidence consistent with the proposition that, in a world in which there is a plentiful supply of undergraduate students with the capacity to pay tuition at U.S. universities, public universities choose to expand the enrollment of foreign students in order to offset the loss of resources from state funding.

For out-of-state domestic students, variation in state appropriations has essentially no effect on first-time undergraduate enrollment. Demographics do matter for out-of-state enrollment: when a state's college age population declines, out-of-state enrollment at public universities increases. For in-state students, the effect of state appropriations on enrollment is modest – point estimates are effectively zero at AAU and flagship universities, while small and positive at public and research universities. Not surprisingly, changes in cohort size lead to less than proportional changes in public university enrollment (Bound and Turner 2007).

Focusing on the change between 2007 and 2012, an interval in which there were substantial changes in state appropriations, Figure 5 illustrates the link between changes in state appropriations and changes in enrollment in the “Public” universities sample. The top panel shows the decidedly negative relationship between foreign enrollment and state appropriations ($\rho = -.524$). With the California universities among those experiencing the largest declines in state

appropriations, they are among those with the largest increases in foreign enrollment. The two following panels show a parallel presentation for out-of-state and in-state students respectively. In each case, there is essentially no link between the appropriation changes and the enrollment variation ($\rho=-.119$ and $\rho=0.034$, respectively).

4.2 The Link Between Foreign Enrollment and Domestic Enrollment

It is natural to ask whether the variation in the enrollment of foreign students leads to a “crowding out” of domestic students, particularly in-state students. As discussed before, under some stronger assumptions, our theoretical model does not predict such an effect. In Table 3, we present specifications in which we regress in-state and out-of-state enrollment on variation in foreign enrollment for the sample of Public, Research, AAU, and Flagship Universities.

Unambiguously, there is no link between foreign enrollment and in-state enrollment: coefficient estimates are consistently small in magnitude and statistically indistinguishable from zero.²⁵

There is evidence that out-of-state enrollment moves positively with foreign enrollment, though such changes are relatively small.

Estimates of enrollment effects, represented by Table 2 and Table 3, should be thought of as specific to the most recent interval in which there is an ample supply of foreign undergraduate students. Indeed, when we split the sample and examine the periods from 1996-2005 and 2006-2012, we find that the estimated effect of appropriations on foreign enrollment in the latter period is larger (more negative) than in the earlier period when the supply of potential students from abroad is likely to be more limited.

²⁵ Notably, our enrollment results parallel those found in the UK by Machin and Murphy (2015) who find that the large rise in international students, particularly those from China, crowded out enrollment of domestic students at the undergraduate level.

4.3 State Appropriations and Educational Expenditures

Changes in state appropriations directly affect a university's budget constraint and, as such, declines in state appropriations would have a negative effect on measures of expenditures – particularly those related to undergraduate education, absent other channels of adjustment in revenues. As we discuss below, the other potential margins for adjustment include increasing tuition charges directly or changing the composition of students to reflect a higher concentration of those students paying the relatively high out-of-state level of tuition.

A first point to establish is that changes in state-level appropriations do indeed negatively impact expenditures on instructional activities. Tables 4 and 5 presents baseline results from regressions of educational expenditures on state appropriations, also including institution and year fixed effects, for each category of public university. If universities did not adjust their revenue sources to lost state appropriations, such changes in expenditures would simply be proportionate to appropriations as a share of the revenue covering a particular expense category. In turn, across universities, appropriations shocks will have the most modest impact at those universities with the most diversified revenue sources, suggesting that changes will be more modest at the AAU subset relative to the overall group of public institutions.

Table 4 shows three types of university expenditures as outcomes: total education and general expenditures (which includes all facets of research and teaching), expenditures for instruction, and expenditures for instructional salaries. For flagship universities, a 10% decline in state appropriations aligns with about a 2% decline in educational expenditures; similarly, effects are in the 1.8% to 1.7% range for the broader categories of public universities (Table 4, Panel A). For the resource-intensive AAU universities, we do not see appropriations shocks linked to expenditure shocks, suggesting that these institutions are more able to accommodate

appropriations changes from other sources, including potential increases in enrollment from foreign students. Focusing on just the salary component of instructional expenditures, a 10% appropriations shock has an effect of about 2% on these expenditures at the broadly defined groups of public universities. Keeping in mind that the instructional expenditures for salaries are the major component of all educational expenditures, such results are consistent with the observation that salary and hiring freezes are a common institutional response to shocks to state appropriations.

Looking at other expenditure categories in Table 5 such as research and academic support services provides evidence about how appropriations shocks are absorbed at public universities, with effects concentrated in those activities tied to student instruction.²⁶ Academic support services -- which includes expense functions such as libraries, administration, and IT services -- are fairly sensitive to changes in appropriations with expenditures falling about 4% in association with a 10% decline in appropriations at the state level. Research activities are not particularly sensitive to state appropriations shocks as we would expect such activities to be funded primarily from revenue streams other than state appropriations.

Our evidence is clear: While changes in state appropriations are inversely related to core instructional expenditure categories, such changes are appreciably less than dollar for dollar.

4.3 State Appropriations and Tuition Revenues

Looking at the period-to-period change between 2007 to 2012, Figure 6 shows a strong negative link between changes in tuition revenues (measured across all enrollment residencies) and state appropriations, with a simple correlation of appropriations $\rho=-0.621$. Institutions such

²⁶ Definitions of expenditure categories appearing in the IPEDS surveys can be found here: <http://nces.ed.gov/ipeds/glossary/?charindex=A>

as the University of California Berkeley that lost the most in state appropriations had the largest gains in tuition revenues.

Summarized in a regression context, the first panel of Table 6 shows the link between state appropriations and total tuition revenue. In log form, this link is negative and of a magnitude of 0.278 for the group of AAU universities, though the estimates are not distinguishable from zero for the broader university collaborations.

Of course, total tuition revenue can change through the channels of “price” or “quantity” where “price” is the tuition levels charged to students of different residencies and quantity is the number of students paying each type of tuition. To the first point, Panels B and C of Table 6 show the effect of changing appropriations on tuition charges, for the in-state and out-of-state rates respectively.²⁷ While all coefficients are negative, they vary in magnitude with the relative changes appreciably larger at the in-state level than for the out-of-state price. For the in-state tuitions (Panel B), a 10% relative decline in appropriations links to about a 3% larger tuition increase at flagship universities with a more modest change at the larger group of research universities. The magnitude of the effect of appropriations on out-of-state tuition is more muted, and the point estimates suggest an elasticity of less than 0.1, with only the estimate for all research universities significant at conventional levels. Figure 7 illustrates the in-state and out-of-state changes in tuition relative to the change in state appropriations.

At question is how changes in foreign students reflect on changes in tuition revenue.

Represented in log form with institution and year fixed effects, there is a modest yet statistically

²⁷ The greater changes in in-state relative to out-of-state tuition levels likely reflect the observation that universities likely have more “market power” with in-state students than out-of-state students who are comparing public universities with private universities across geographic markets. However, it would be incorrect to assert that in-state adjustments are simply an exercise of market power. The magnitude of such adjustments are likely muted by strong political forces and the observation that an institution’s net revenue change will be much more modest if financial aid adjusts accordingly or, without such financial aid adjustments, the institution becomes much less affordable to low and moderate income students in the state.

significant link between changes in the enrollment of foreign students and tuition revenues among the AAU universities (Table 7, Panel A).

A different framework for viewing these results is with tuition revenues and enrollment in levels. In effect, this is an accounting exercise in which we would expect changes in enrollment to produce changes in tuition revenue mirroring group-specific prices. Indeed, such changes are clearly visible in a regression framework as presented in Table 7. What we find is that foreign undergraduate students generate additional revenue fairly closely aligned with the “sticker price” of out-of-state tuition. In contrast, tuition revenues generated by additional out-of-state domestic students are far less than the “sticker price”, presumably because some discounts – either merit aid or need-based financial aid are required to attract them to study.

4.4 Supplemental Results (and Questions)

In our theoretical model, we assumed an inelastic supply of foreign students at a given level of quality. Ideally, we would be able to examine both the incremental achievement of foreign students and the relative achievement of foreign, in-state and domestic out-of-state students at the margin of admission. Data do not permit such an analysis in all but a few anecdotal cases. What we are able to measure is the achievement (interquartile range of test scores) of each entering cohort by university. Universities differ in whether the primary testing instrument is the ACT, which reports a composite score over different subjects, or the SAT, which distinguishes math and verbal performance. In brief, we find that increasing foreign enrollment leads to little change in the ACT scores and very modest changes in SAT scores, which are distinguished by math and verbal components. There are modest gains in the math scores at the 25th percentile and attenuation in verbal scores at the 25th percentile, though this finding is perhaps unsurprising given that many foreign students are not native English speakers.

It is worth underscoring that these effects are quite small even when statistically significant. Still, there are important open questions about the peer effects generated by a large influx of foreign students in terms of social interactions and choice of major.

4.4 Accounting for the Changing Tuition Revenues

The empirical evidence is clear in demonstrating that shocks to state appropriations at public universities produce adjustments along multiple margins, including growth in likely “full pay” undergraduates from abroad. A natural question concerns just how quantitatively important is this channel of adjustment to different universities. Looking to understand the difference between the pre-Great Recession academic year 2007-08 to 2012-13, we consider the change in tuition revenues per student generated from the following sources: i) the change in the share of foreign undergraduates, ii) the change in the share of out-of-state undergraduates, iii) the change in the tuition charged to foreign and domestic out-of-state students and iv) the change in in-state tuition levels. This decomposition can be expressed as:

$$\Delta \frac{\textit{Tuition Revenue}}{\textit{Students}} = (\Delta s_o \times \overline{D}_t) + (\Delta s_f \times \overline{D}_t) + (\overline{s}_o \times \Delta D_t) + (\overline{s}_f \times \Delta D_t) + \Delta T_i$$

where D_t is the difference between in-state and out-of-state tuition, s_o is the out-of-state domestic share of undergraduate enrollment, s_f is the foreign share of total undergraduate enrollment, $1 - s_o - s_f$ is the share of in-state enrollment (s_i), and T_i is in-state tuition. Overbar notation represents an average over two years while delta indicates the change over time. We deflate all monetary variables by the CPI.

We focus the exercise on the AAU universities and, in Table 8, we divide each right-hand side term by the total change in tuition revenue per student to show the percent of the tuition revenue change accounted for by each component (columns (1)-(5)) The final two columns of the table show the change in appropriations per undergraduate student and the change in tuition

revenues per undergraduate student. Changes in total tuition revenues accounted for a sizable share of the loss in state appropriations though somewhat less than 100% at most institutions; in a few cases such as the University of Illinois and University of Colorado it would appear that changes in total tuition revenue actually exceeded the negative shock in appropriations.²⁸

The measures shown reflect the relative importance of changes in the different price levels for in-state and out-of-state students along with the changes in the student representation. In nearly all cases, the in-state tuition changes form the quantitative majority of revenue changes – on average, such changes account for about less than 56% of the change in tuition revenues, as show in the fifth column of Table 9. This follows from the combination of in-state price increases induced by the appropriations shocks (see Table 6) and the majority of students from in-state at public universities.

Turning to the role of the change in foreign students (represented in column (1)), the overall role of the increase in foreign students is to account for about 22% of the change in tuition revenues, on average. Notably, there are a modest number of universities such as the University of Illinois, Indiana, and Ohio State where the change in foreign students accounts for well over 40% of the change in tuition revenues over the interval.

Section 5. Conclusion

The dramatic increase in foreign undergraduates at U.S. public universities is closely coupled with institutional adjustment to changes in state appropriations. Overall, increases in foreign enrollment over the last decade are much larger in the public university sector than in other parts of the higher education market, including private liberal arts colleges and private

²⁸ A word of caution is appropriate: Increases in net tuition revenue are often substantially less than changes in gross tuition revenue when institutions are committed to substantial need-based financial aid. A second caution is tied to the observation that our tuition revenue numbers are for all students, not just undergraduate students.

research universities. The theoretical framework and evidence presented in this analysis suggests that expanding foreign enrollment at the undergraduate is an important channel through which public universities are able to buffer changes in state appropriations.

While we are not able to do a full welfare analysis, our results do not indicate that the added revenue from foreign students comes at the cost of fewer in-state undergraduates. Because the number of in-state undergraduates and the quality of the instructional opportunities are likely arguments in the objective function of a public university, these results suggest that while added foreign students do not fully offset the adverse consequences of negative shocks to state appropriations.

The capacity of public universities to utilize this margin of adjustment depends critically on a significant pool of well-qualified potential undergraduates from abroad with the capacity to pay the tuition charged by U.S. universities. While there has been a deep pool of such students in the last decade owing primarily to the demographic and economic changes in countries like India and China, this reservoir of talent and resources did not emerge in full force until the millennium. What is more, the supply of such students to U.S. education is not a constant in future decades. Growth in home-country institutions of close quality or negative shocks to home-country economies would likely lead to an evaporation of this pool of students from abroad.

References

- Barr, Andrew and Sarah Turner. 2013. "Expanding Enrollments and Contracting Budgets: The Effect of the Great Recession Higher Education," *The Annals: American Academy of Political and Social Science* Vol. 650 (1):168-193.
- Bird, K. and S. Turner. 2014. "College in the States: Foreign Student Demand and Higher Education Supply in the U.S." EdPolicyWorks Working Paper Series No. 23.
- Bound, John and Turner, Sarah, 2007. "Cohort crowding: How resources affect collegiate attainment," *Journal of Public Economics*, Elsevier, vol. 91(5-6), pages 877-899, June.
- Bound, John; Brad Hershbein and Bridget Terry Long, 2009. "Playing the Admissions Game: Student Reactions to Increasing College Competition," *Journal of Economic Perspectives*, American Economic Association, vol. 23(4), pages 119-46, Fall.
- Bound, J., M. Demirci, G. Khanna, and S. Turner. 2014. "Finishing Degrees and Finding Jobs: U.S. Higher Education and the Flow of Foreign IT Workers"
<http://nber.org/confer/2014/IPEs14/bound.pdf>
- Epple, Dennis; Richard Romano, Sinan Sarpça, and Holger Sieg. The US Market for Higher Education: A General Equilibrium Analysis of State and Private Colleges and Public Funding Policies. No. w19298. National Bureau of Economic Research, 2013.
- Epple, Dennis; Richard Romano, and Holger Sieg. "Admission, tuition, and financial aid policies in the market for higher education." *Econometrica* 74, no. 4 (2006): 885-928.
- Fischer, Karen. 2014 "Chinese Students Lead Foreign Surge at U.S. Colleges" *New York Times* (November 30)
- Goldin, Claudia and Lawrence F. Katz. 1999. "The Shaping of Higher Education: The Formative Years in the United States, 1890 to 1940." *Journal of Economic Perspectives* 13(1): 37-62.
- Goldin, Claudia and Lawrence F. Katz. 2008. *The Race Between Education and Technology*. Harvard University Press.
- Higgins, Tim. 2013. "Chinese Students Major in Luxury Cars." *Bloomberg Business*. (December 19) <http://www.bloomberg.com/bw/articles/2013-12-19/chinese-students-in-u-dot-s-dot-boost-luxury-car-sales>
- Hoover, Eric and Josh Keller. 2011. "More Students Migrate Away from Home." *The Chronicle of Higher Education* (October 30)
- Hwang, J. E. 2009. "MIT or Tsinghua? A panel data analysis of the determinants of domestic higher education and international student mobility." Department of Economics, Harvard College.

Jacob, Brian and Brian McCall and Kevin Stange . 2013. "College as Country Club: Do Colleges Cater to Students' Preferences for Consumption?" NBER Working Paper No. 18745 January.

Kane, Thomas; Peter R. Orszag, Emil Apostolov. 2005. "Higher Education Appropriations and Public Universities: Role of Medicaid and the Business Cycle" *Brookings-Wharton Papers on Urban Affairs*, pp. 99-146

Kurtz, S. 2012. "Thanks to scholarship, Saudi students to U.S. in droves." *The Washington Diplomat*, August 21, 2012.

LaFraniere, S. 2009. "China's college entry test is an obsession." *The New York Times*, June 12, 2009.

Lewin, T. 2011. "Universities Seeking Out Students of Means." *The New York Times* (September 21).

Liu, Yi-Ling. 2015. "China's Nouveau Riche Have Landed on America's Campuses" *Foreign Policy* (September 1)

Machin, Stephen and Richard Murphy. 2015. "Paying Out or Crowding Out? The Globalisation of Higher Education." Mimeo.

Okunade, A 2004. "What factors influence state appropriations for public higher education in the United States?" *Journal of Education Finance* Vol. 30, No. 2 (Fall), pp. 123-138.

Rosenzweig, M. R. 2006. "Global Wage Differences and International Student Flows." *Brookings Trade Forum*, pp. 57-86.

Rothschild, M. and L. J. White. 1995. "The Analytics of Pricing in Higher Education and Other Services in Which Customers are Inputs." *Journal of Political Economy* 103.

Sallee, James M., Alexandra A. Resch, and Paul N. Courant. 2008. "On the Optimal Allocation of Students and Resources in a System of Higher Education." *The B.E. Journal of Economic Analysis & Policy* 8(1), Advances, Article 11.

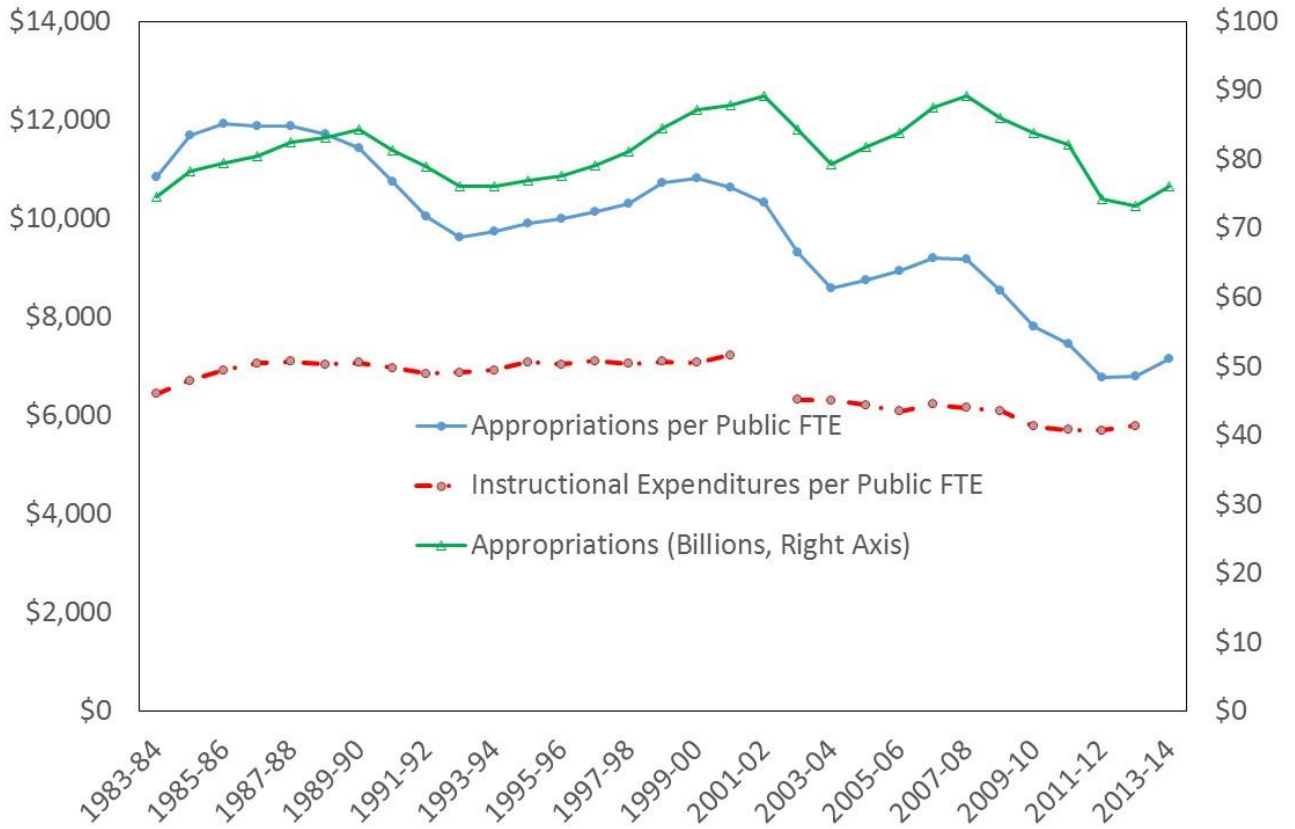
Seegert, Nate. 2015. "Optimal Taxation with Volatility a Theoretical and Empirical Decomposition." Working Paper.

Schworm, P. 2008. "Foreign students flock to the US: Surge in overseas applicants driven by weak dollar." *The Boston Globe*: July 5th, 2008.

The Economist. 2013. "Beyond Bling." *The Economist Newspaper Limited*, June 8, 2013.

Winston, Gordon and David Zimmerman. 2004 "Peer Effects in Higher Education," in *College Choices: The Economics of Where to Go, When to Go, and How to Pay For It*, Chicago and London: University of Chicago Press, 2004.

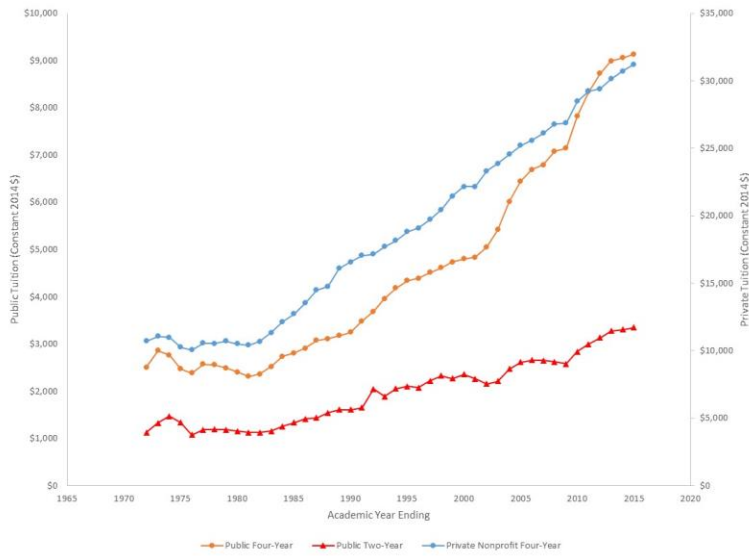
Figure 1. Appropriations and Instructional Expenditures Over Time, 1983-2012



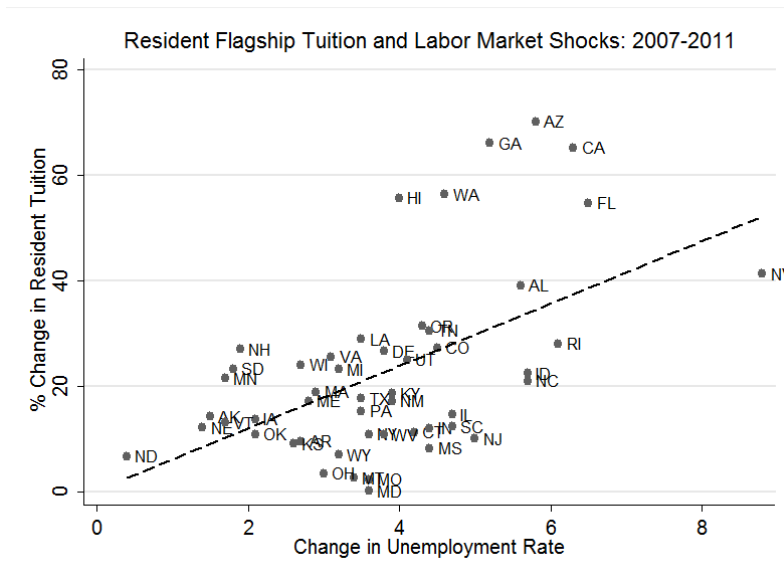
Source: *Trends in College Pricing* and *Digest of Education Statistics*, various years. All figures are deflated by the Higher Education Price Index (HEPI).

Figure 2: Tuition and Fees over Time

Panel A: Trend over time



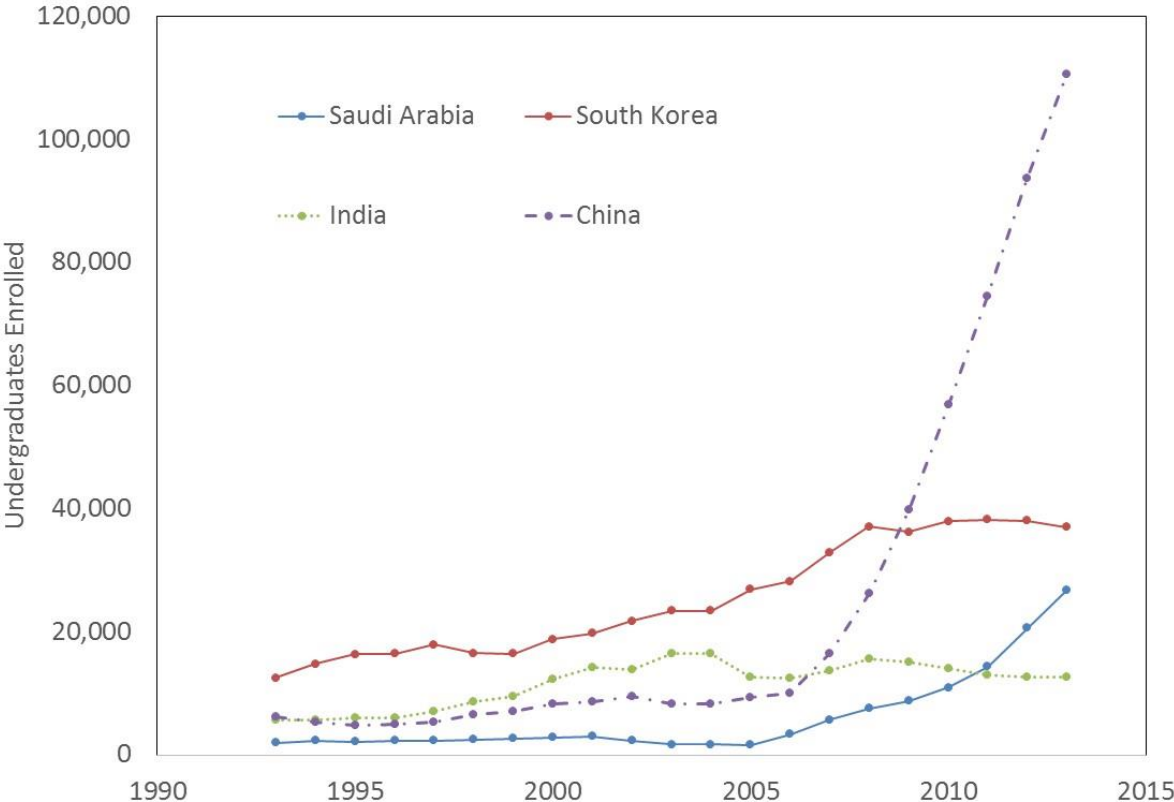
Panel B: Resident Flagship Tuition and Labor Market Shocks (2007 to 2011)



Note: Both changes are measured from 2007 (i.e., 2007-2008 school-year) to 2011.

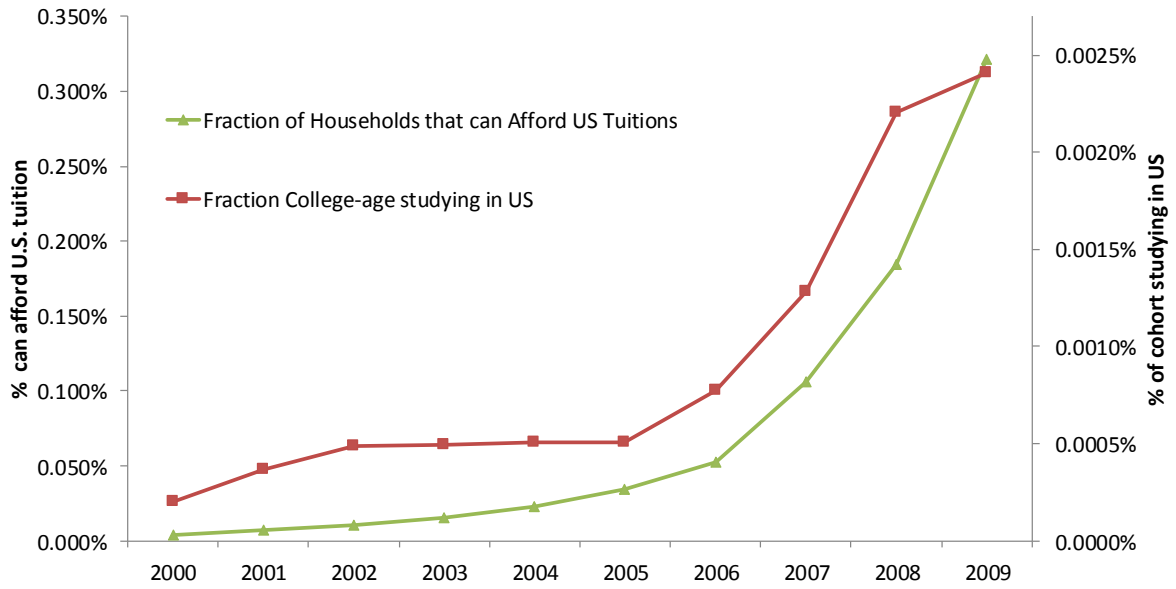
Source: *Trends in College Pricing*, Table 6.

Figure 3: Country trends in foreign undergraduate enrollment at U.S. higher education institutions, 1992-2013



Source: *Open Doors*, Institute for International Education, various years.

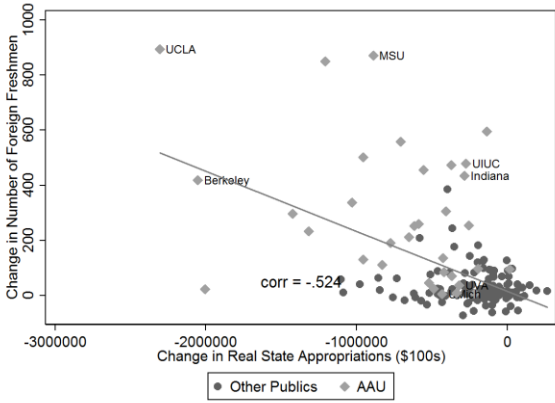
Figure 4. Fraction of Chinese college-age population studying abroad and financial capacity, 2000-2009



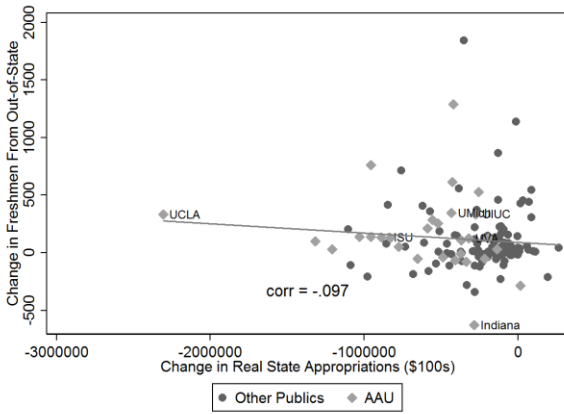
Source: Authors' calculations, based on income distribution data from the World Bank and Average Tuition Out-of-State Student in a Public University + Room and Board from IPEDs.

Figure 5. Enrollment by Residency and State Appropriations, 2007 to 2012

Panel A. Foreign Freshmen



Panel B. Out-of-State Freshmen



Panel C. In-State Freshmen

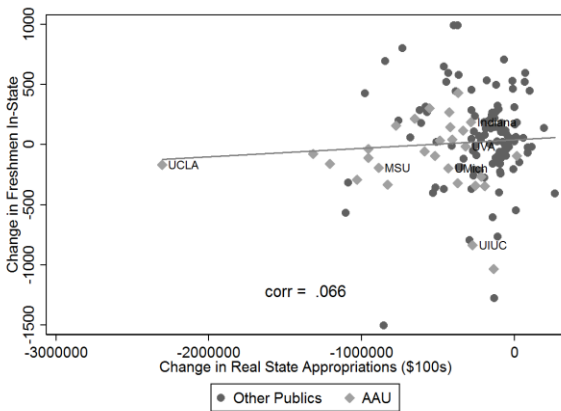


Figure 6. Change in Appropriate and Tuition, 2007 to 2012

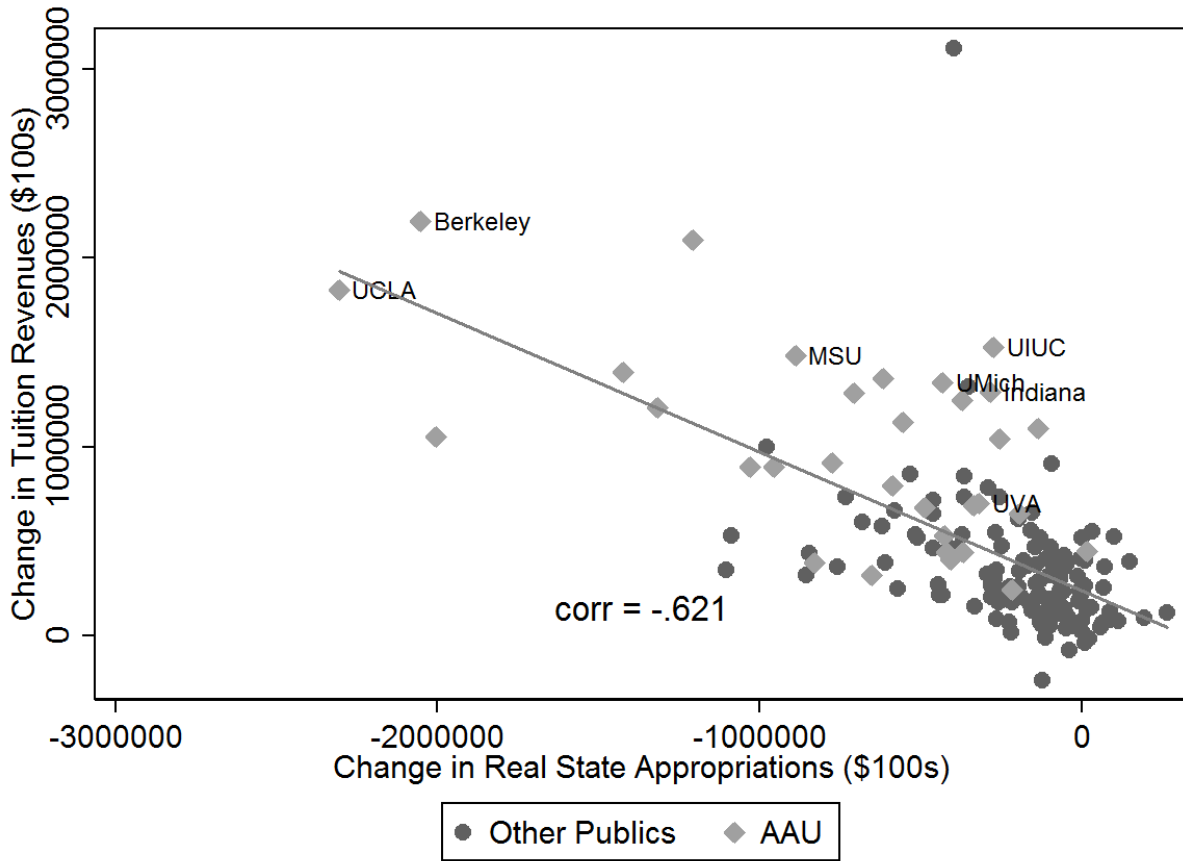
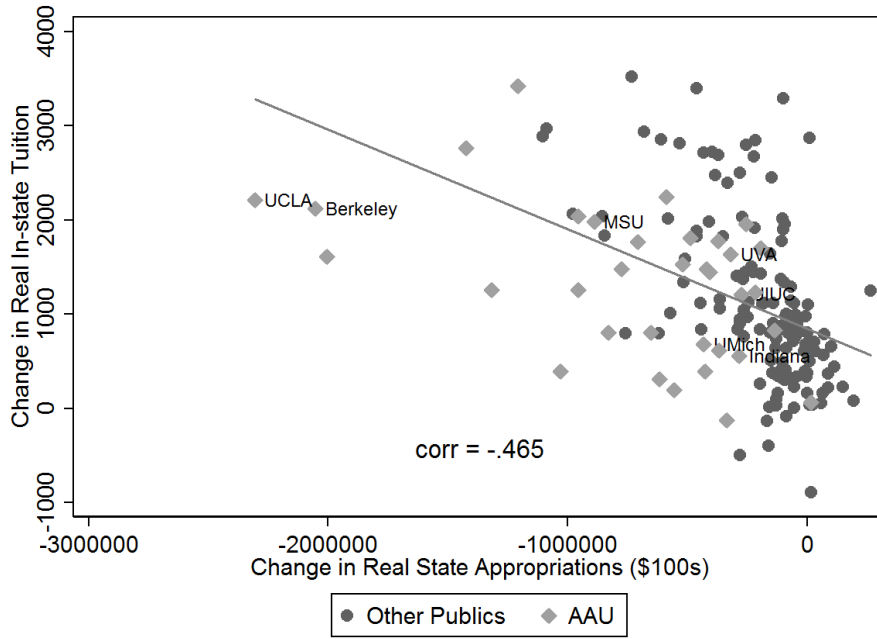


Figure 7. Change in Appropriations and Tuition Levels, 2007 to 2012

A. In-State



B. Out-of-State

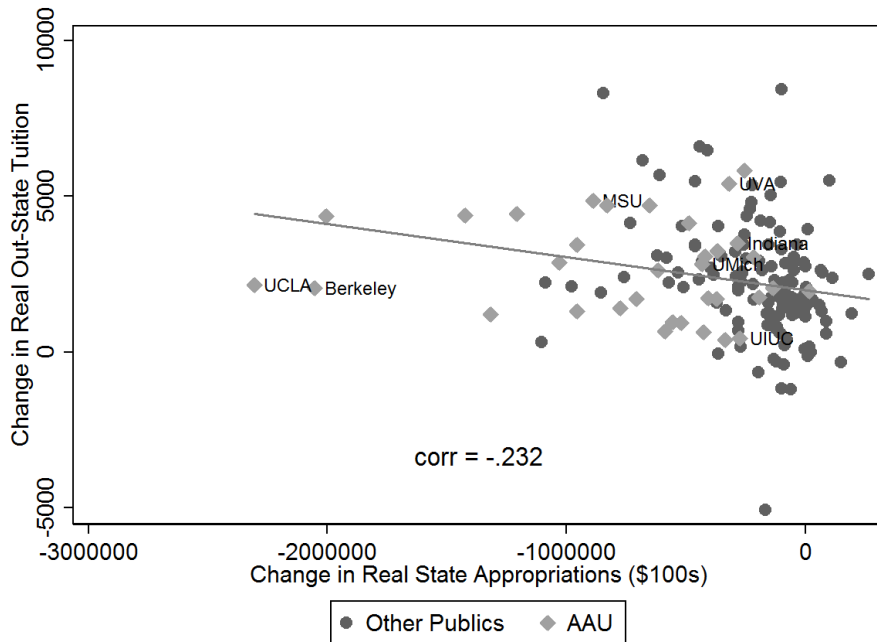


Table 1. Representation of Out-of-State and Foreign at AAU Public Universities

Institution Name	Percent Out-of-State Among Domestic			Percent Foreign		
	1996	2006	2012	1996	2006	2012
Georgia Institute of Technology-Main Campus	32.00	30.74	35.09	2.74	9.31	13.93
Indiana University-Bloomington	31.16		29.15	3.51		9.37
Iowa State University	22.80	27.59	34.76	2.35	1.53	4.66
Michigan State University	7.11	10.78	11.22	1.60	3.79	15.35
Ohio State University-Main Campus	11.80	13.54	16.69	1.64	1.18	8.08
Pennsylvania State University-Main Campus	29.59	29.73	32.83	1.33	2.38	9.74
Purdue University-Main Campus	22.98	30.33	29.49	3.39	5.55	15.34
Rutgers University-New Brunswick	10.73	8.17	8.02	1.78	1.93	5.17
Stony Brook University	2.61	8.06	11.43	3.11	4.78	10.46
Texas A & M University-College Station	6.00	4.46	3.40	0.89	0.90	0.61
The University of Texas at Austin	7.14	5.45	7.14	1.51	3.37	3.81
University at Buffalo	3.01	4.75	4.06	1.23	8.21	13.82
University of Arizona	36.45	35.53	34.74	1.30	1.91	4.93
University of California-Berkeley	7.45	6.35	13.82	1.84	3.01	14.80
University of California-Davis	1.79	2.00	1.67	0.43	1.87	5.91
University of California-Irvine	1.00	1.41	2.27	4.15	8.02	11.94
University of California-Los Angeles	3.68	6.38	9.72	0.83	1.37	18.61
University of California-San Diego	2.15	4.10	7.80	0.45	0.96	14.91
University of California-Santa Barbara	3.77	4.12	5.91	0.58	0.56	4.94
University of Colorado Boulder	43.31	40.30	39.18	0.95	1.04	3.34
University of Florida	11.04	6.80	6.45	5.69	5.98	5.23
University of Illinois at Urbana-Champaign	9.71	6.37	11.30	0.77	5.06	13.21
University of Iowa	34.63	41.94	43.62	0.65	0.65	8.90
University of Kansas	30.68	26.03	28.37	1.92	1.88	3.18
University of Maryland-College Park	33.98	29.43	29.59	8.17	1.62	1.87
University of Michigan-Ann Arbor	33.45	30.97	37.22	5.14	5.00	4.57
University of Minnesota-Twin Cities	30.08	33.57	32.28	1.49	1.29	5.20
University of Missouri-Columbia	16.40	19.70	34.90	0.27	0.60	2.09
University of North Carolina at Chapel Hill		14.63	15.35		1.26	1.23
University of Oregon	31.32	30.03	40.49	6.01	5.00	11.14
University of Pittsburgh-Pittsburgh Campus	19.81	24.59	30.25	0.65	0.50	2.36
University of Virginia-Main Campus	32.22	30.60	29.38	2.09	5.69	5.56
University of Washington-Seattle Campus	13.01	19.74	16.14	1.51	1.72	16.97
University of Wisconsin-Madison	31.99	36.79	34.89	2.29	3.81	9.30

Table 2: Effects of changes in state appropriations on first-time undergraduate enrollment, 1996-2012

	Ln Foreign 1st Year Enrollment			
	AAU	Flagships	Public	Research
Log(State Appropriations)	-0.672 (0.323)**	-0.888 (0.312)***	-0.445 (0.175)**	-0.622 (0.180)***
Log(Population 18)	-1.268 (0.677)*	0.030 (0.439)	0.227 (0.304)	0.121 (0.314)
Constant	24.291 (8.758)***	10.164 (5.206)*	4.275 (3.598)	6.890 (3.687)*
R-squared	0.634	0.473	0.312	0.367
	Ln Out-of-State 1st Year Enrollment			
	AAU	Flagships	Public	Research
Log(State Appropriations)	0.284 (0.267)	-0.046 (0.232)	0.023 (0.131)	0.057 (0.143)
Log(Population 18)	-0.696 (0.465)	-0.739 (0.318)**	-0.613 (0.203)***	-0.692 (0.214)***
Constant	12.441 (4.939)**	14.988 (3.744)***	12.551 (2.231)***	13.380 (2.352)***
R-squared	0.227	0.298	0.205	0.230
	Ln In-State 1st Year Enrollment			
	AAU	Flagships	Public	Research
Log(State Appropriations)	0.018 (0.060)	0.012 (0.052)	0.121 (0.050)**	0.090 (0.052)*
Log(Population 18)	0.504 (0.160)***	0.168 (0.154)	0.613 (0.100)***	0.601 (0.106)***
Constant	2.098 (1.853)	5.885 (1.757)***	-0.167 (1.173)	0.262 (1.277)
Observations	508	700	2,393	1,946
R-squared	0.363	0.324	0.394	0.399
Number of unitid	34	48	172	136

Notes: All regressions include institution and year fixed effects. Institution-year observations are weighted by the undergraduate population at baseline (1996). Robust standard errors clustered at the university level are reported in parentheses.

Table 3: Estimates of the effect of enrollment and cohort size on in-state and out-of-state enrollment levels, 1996-2012

	Log(Freshmen From Out-of-State)			
	AAU	Flagships	Public	Research
Log(Foreign Freshmen)	0.116 (0.053)**	0.006 (0.044)	0.083 (0.022)***	0.092 (0.024)***
Log(Population 18)	-0.444 (0.386)	-0.760 (0.316)**	-0.630 (0.193)***	-0.680 (0.202)***
Constant	11.173 (4.553)**	14.839 (3.468)***	12.596 (2.184)***	13.293 (2.295)***
R-squared	0.247	0.301	0.221	0.248
	Log(Freshmen In-State)			
	AAU	Flagships	Public	Research
Log(Foreign Freshmen)	0.002 (0.015)	-0.004 (0.015)	0.002 (0.010)	-0.007 (0.012)
Log(Population 18)	0.470 (0.167)***	0.157 (0.154)	0.642 (0.105)***	0.615 (0.112)***
Constant	2.620 (1.972)	6.111 (1.713)***	0.352 (1.205)	0.771 (1.282)
Observations	512	705	2,457	2,001
R-squared	0.351	0.322	0.376	0.380
Number of unitid	34	48	173	137

Notes: All regressions include institution and year fixed effects. Institution-year observations are weighted by the undergraduate population at baseline (1996). Robust standard errors clustered at the university level are reported in parentheses.

Table 4: Estimates of the effect of changes in state appropriations and cohort size on in-state on university instructional expenditure categories, 1996-2012

	Log(Total education and general expenditures)			
	AAU	Flagships	Public	Research
Log(State Appropriations)	-0.021 (0.051)	0.196 (0.107)*	0.181 (0.079)**	0.168 (0.088)*
Log(Population 18)	0.249 (0.195)	-0.034 (0.106)	0.208 (0.089)**	0.181 (0.094)*
Constant	18.557 (2.258)***	19.944 (1.126)***	16.784 (0.868)***	17.317 (0.925)***
R-squared	0.949	0.860	0.872	0.871
	Log(Instructional Expenditures)			
	AAU	Flagships	Public	Research
Log(State Appropriations)	-0.016 (0.068)	0.142 (0.114)	0.151 (0.077)*	0.147 (0.086)*
Log(Population 18)	0.077 (0.205)	0.005 (0.121)	0.193 (0.099)*	0.191 (0.106)*
Constant	19.585 (2.526)***	18.873 (1.451)***	16.178 (1.054)***	16.339 (1.129)***
R-squared	0.926	0.863	0.871	0.868
	Log(Instructional - salaries and wages)			
	AAU	Flagships	Public	Research
Log(State Appropriations)	0.075 (0.049)	0.193 (0.097)*	0.186 (0.075)**	0.184 (0.084)**
Log(Population 18)	0.116 (0.249)	0.022 -0.143	0.299 (0.105)***	0.284 (0.111)**
Constant	17.909 (2.951)***	17.813 (1.590)***	14.218 (1.109)***	14.517 (1.194)***
R-squared	0.944	0.850	0.788	0.779
Observations	446	654	2,171	1,719

Notes: All regressions include institution and year fixed effects. Institution-year observations are weighted by the undergraduate population at baseline (1996). Robust standard errors clustered at the university level are reported in parentheses.

Table 5: Estimates of the effect of changes in state appropriations and cohort size on in-state on university non-instructional expenditure categories, 1996-2012

	Log(Expenditures for support services - current year total)			
	AAU	Flagships	Public	Research
Log(State Appropriations)	0.240 (0.091)**	0.315 (0.102)***	0.398 (0.085)***	0.367 (0.092)***
Log(Population 18)	-0.757 (0.298)**	-0.486 (0.210)**	-0.343 (0.163)**	-0.400 (0.176)**
Constant	25.976 (3.548)***	21.576 (2.165)***	19.076 (1.837)***	20.022 (1.989)***
R-squared	0.773	0.727	0.692	0.683
	Log(Expenditures for research - current year total)			
	AAU	Flagships	Public	Research
Log(State Appropriations)	-0.029 (0.116)	0.187 (0.218)	0.071 (0.153)	0.042 (0.169)
Log(Population 18)	0.210 (0.252)	-0.206 (0.157)	0.039 (0.176)	0.088 (0.186)
Constant	17.697 (2.934)***	20.409 (1.651)***	17.700 (1.710)***	17.644 (1.765)***
R-squared	0.916	0.713	0.610	0.609
Observations	446	654	2,171	1,719

Notes: All regressions include institution and year fixed effects. Institution-year observations are weighted by the undergraduate population at baseline (1996). Robust standard errors clustered at the university level are reported in parentheses.

Table 6: Estimates of the effect of changes in state appropriations and cohort size on in-state on university non-instructional expenditure categories, 1996-2012

	A. Ln (Tuition Revenue)			
	AAU	Flagships	Public	Research
Log(State Appropriations)	-0.278 (0.078)***	-0.140 (0.090)	-0.045 (0.058)	-0.086 (0.062)
Log(Population 18)	0.121 (0.152)	-0.080 (0.135)	0.323 (0.112)***	0.305 (0.122)**
Constant	19.704 (2.164)***	20.543 (1.722)***	14.892 (1.366)***	15.533 (1.501)***
R-squared	0.885	0.847	0.802	0.812
	B. Ln (In-State Tuition)			
	AAU	Flagships	Public	Research
Log(State Appropriations)	-0.307 (0.130)**	-0.253 (0.085)***	-0.238 (0.053)***	-0.262 (0.058)***
Log(Population 18)	1.046 (0.264)***	0.642 (0.221)***	0.763 (0.120)***	0.749 (0.126)***
Constant	-1.863 (3.353)	2.827 (2.523)	0.874 (1.346)	1.289 (1.407)
R-squared	0.906	0.901	0.864	0.887
	C. Ln (Out-of-state tuition)			
	AAU	Flagships	Public	Research
Log(State Appropriations)	0.014 (0.114)	0.036 (0.069)	-0.060 (0.043)	-0.044 (0.045)
Log(Population 18)	0.829 (0.297)***	0.351 (0.214)	0.189 (0.103)*	0.206 (0.110)*
Constant	-0.544 (3.789)	5.038 (2.346)**	7.375 (1.095)***	7.104 (1.167)***
R-squared	0.891	0.884	0.886	0.894
Observations	561	798	2,824	2,231
Number of unitid	34	48	172	136

Notes: All regressions include institution and year fixed effects. Institution-year observations are weighted by the undergraduate population at baseline (1996). Robust standard errors clustered at the university level are reported in parentheses.

Table 7: Changes in enrollment and tuition revenues

	A. Ln (Tuition Revenue)			
	AAU	Flagships	Public	Research
Log(Foreign Freshmen)	0.065 (0.018)***	0.044 (0.016)***	0.022 (0.009)**	0.016 (0.010)
Log(Population 18)	0.119 (0.154)	-0.082 (0.137)	0.305 (0.115)***	0.277 (0.124)**
Constant	17.308 (1.835)***	19.345 (1.498)***	14.715 (1.308)***	15.172 (1.410)***
R-squared	0.887	0.850	0.806	0.813
	B. Tuition Revenue (Levels)			
	AAU	Flagships	Public	Research
In-state Undergrads	5,793.800 (3,135.932)*	3,628.171 (3,685.916)	1,812.029 (1,136.888)	1,659.048 (1,181.129)
Out-state Undergrads	18,789.221 (5,897.438)***	16,265.743 (4,579.944)***	13,271.451 (2,277.723)***	13,697.091 (2,388.259)***
Non-resident Undergraduate:	42,593.561 (14,513.221)***	62,083.031 (16,359.805)***	38,883.796 (10,907.226)***	38,901.648 (11,049.516)***
US Graduate Students	13,670.415 (7,768.566)*	5,835.154 (9,281.453)	16,141.192 (3,384.037)***	16,664.739 (3,503.789)***
Foreign Graduate Students	5,604.850 (18,754.759)	33,769.243 (20,378.174)	32,860.702 (9,017.068)***	33,754.493 (9,232.031)***
Constant	-3.412e+07 (50110914.836)	-2.000e+07 (28832834.358)	2020245.099 (11884181.664)	-272,232.367 (13495944.302)
Observations	229	330	1,163	943
R-squared	0.582	0.751	0.793	0.774

Notes: All regressions include institution and year fixed effects. Institution-year observations are weighted by the undergraduate population at baseline (1996). Robust standard errors clustered at the university level are reported in parentheses.

Table 8: Changes in foreign enrollment and incoming first-year test scores

	Log(ACT Composite - 25th percentile)			
	AAU	Flagships	Public	Research
Log(Foreign Freshmen)	0.001 (0.006)	0.004 (0.005)	0.001 (0.002)	0.000 (0.003)
Log(Population 18)	-0.111 (0.065)*	-0.072 (0.044)	-0.020 (0.029)	-0.024 (0.030)
Constant	4.423 (0.762)***	3.852 (0.474)***	3.237 (0.329)***	3.298 (0.340)***
R-squared	0.612	0.539	0.413	0.442
	Log(SAT I Math - 25th percentile)			
	AAU	Flagships	Public	Research
Log(Foreign Freshmen)	0.003 (0.004)	0.010 (0.005)*	0.006 (0.002)**	0.005 (0.003)**
Log(Population 18)	-0.176 (0.041)***	-0.071 (0.037)*	-0.035 (0.023)	-0.038 (0.024)
Constant	8.344 (0.491)***	6.991 (0.404)***	6.578 (0.265)***	6.626 (0.274)***
R-squared	0.650	0.499	0.353	0.388
	Log(SAT I Verbal - 25th percentile)			
	AAU	Flagships	Public	Research
Log(Foreign Freshmen)	-0.018 (0.005)***	-0.011 (0.005)*	-0.005 (0.002)**	-0.008 (0.003)***
Log(Population 18)	-0.033 (0.049)	-0.009 (0.033)	0.024 (0.022)	0.021 (0.022)
Constant	6.722 (0.574)***	6.375 (0.353)***	5.937 (0.243)***	5.990 (0.250)***
R-squared	0.235	0.193	0.117	0.146
Observations	421	586	2,002	1,655
Number of unitid	29	45	153	122

Notes: All regressions include institution and year fixed effects. Institution-year observations are weighted by the undergraduate population at baseline (1996). Robust standard errors clustered at the university level are reported in parentheses.

Table 9: Decomposing per Student Changes in Tuition Revenues, 2007-2012

Institution Name	$\Delta s_f * Dt$	$\Delta s_o * Dt$	$s_f * \Delta Dt$	$s_o * \Delta Dt$	ΔT	$\Delta \left(\frac{App}{Ugrad} \right)$	$\Delta \left(\frac{Rev}{Ugrad} \right)$
University of Arizona	8.5%	-18.1%	1.8%	14.9%	93.0%	-2492	1265
UC-Berkeley	35.9%	4.8%	-0.4%	-0.8%	60.4%	-3868	1465
UC-Davis	22.3%	9.4%	-0.3%	-0.4%	69.0%	-2892	738
UC-Irvine	25.7%	-7.8%	-0.4%	-0.3%	82.8%	-877	889
UC-Los Angeles	25.7%	20.7%	-0.3%	-0.3%	54.3%	-4341	1707
UC-San Diego	34.1%	5.9%	-0.3%	-0.3%	60.6%	-1551	1204
UC-Santa Barbara	17.0%	0.0%	-0.2%	-1.3%	84.5%	-1945	716
U Colorado Boulder	8.8%	35.5%	-0.1%	-1.5%	57.4%	-336	1242
University of Florida	-0.3%	-10.0%	1.6%	8.1%	100.6%	-2190	676
Georgia Tech	30.1%	-6.4%	-4.4%	-26.2%	106.8%	-2831	890
U Illinois - UC	46.6%	2.8%	-2.0%	-4.1%	56.6%	-519	857
Indiana University	49.1%	-43.1%	9.1%	53.1%	31.9%	-612	663
Iowa State University	27.2%	46.6%	0.4%	2.0%	23.7%	-1605	613
University of Iowa	31.5%	22.4%	2.6%	30.4%	13.0%	-2268	1121
University of Kansas	13.2%	-5.2%	3.5%	22.9%	65.6%	-309	769
University of Maryland	28.9%	-73.8%	14.3%	132.0%	-1.5%	-182	138
University of Michigan	14.7%	19.3%	4.8%	31.3%	29.9%	-1006	833
Michigan State University	25.2%	3.8%	3.8%	7.4%	59.8%	-1195	1368
University of Minnesota	19.1%	-3.0%	1.6%	12.8%	69.5%	-1863	1220
University of Missouri	5.1%	28.5%	1.0%	8.6%	56.8%	-1531	1071
Rutgers University	23.1%	-17.2%	10.2%	37.9%	46.1%	-1923	206
University at Buffalo	26.2%	0.0%	19.7%	6.9%	47.3%	-1888	700
Stony Brook University	12.2%	13.2%	13.0%	10.4%	51.1%	-2715	648
University North Carolina	6.9%	5.5%	1.2%	15.2%	71.2%	-1779	1078
Ohio State University	63.8%	12.8%	3.0%	7.1%	13.3%	-1034	375
University of Oregon	12.9%	29.9%	4.2%	19.1%	33.9%	-878	2433
Pennsylvania State	24.1%	26.2%	-0.1%	-0.7%	50.5%	-1340	967
University of Pittsburgh	9.1%	32.3%	-0.4%	-5.0%	63.9%	-1492	953
Texas A & M University	-1.0%	39.0%	-2.1%	-5.7%	69.8%	-697	-108
University Texas-Austin	10.5%	0.0%	10.9%	15.1%	63.6%	-627	363
University of Virginia	7.7%	-6.2%	5.7%	36.8%	55.9%	-1262	1212
University of Washington	23.6%	0.0%	0.8%	2.3%	73.3%	-2261	1984
University of Wisconsin	18.2%	12.5%	0.3%	2.7%	66.3%	-677	901
Purdue University	44.0%	17.6%	2.8%	9.8%	25.7%	-119	1281

Notes: All changes between years 2007 and 2012. s_f represents share of undergraduate population that is non-resident alien. s_o represents share of undergraduate population that is out of state domestic students. ΔT is the change in in-state tuition rates. Dt is the tuition differential between out-of-state and in-state tuitions. $\Delta \left(\frac{App}{Ugrad} \right)$ is the change in appropriations per undergraduate between 2007 and 2012. $\Delta \left(\frac{Rev}{Ugrad} \right)$ is the change tuition revenues per undergraduate between 2007 and 2012.