A Passage to America: University Funding and International Students*

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Abstract: Substantial state subsidies to public higher education in the United States have historically allowed in-state students at public colleges and universities to pay significantly lower tuition and fee levels than their out-of-state counterparts. With the marked decline in state appropriations for higher education in recent years, some university leaders are faced with the choice between increasing tuition levels, cutting expenditures – and thereby reducing resources per student, or enrolling a greater proportion of students paying full out-of-state tuition. With strong economic growth in countries like China and India, the pool of undergraduate students from abroad who are academically and financially prepared to attend U.S. colleges has increased markedly in the last decade. In this paper, we examine whether declines in state appropriations have led public universities to enroll 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 12% at public research universities and about 17% at the resource-intensive AAU public universities. These increases in foreign enrollment are associated with declines in in-state enrollment at the relatively selective institutions among public universities. Our empirical results, in combination with a model of university behavior, tell a compelling story about the link between changes in state funding and foreign enrollment in recent years.

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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 their counterparts who are not state residents. State appropriations, however, have not only decreased as a share of the total costs of higher education in recent decades, but also have declined in constant dollars in recent years – falling from $89.7 billion for the 2007-08 academic year to $74.8 billion in 2011-12 (State Higher Education Executive Officers Association, 2014).[1] The most acute effects of the decline in appropriations have been felt in states that faced the most severe recessionary conditions. For university leaders facing declines in state funding, potential margins for adjustment include raising revenues through increases in tuition, cutting expenditures (and thereby reducing resources per student), or admitting a greater proportion of students paying full out-of-state tuition. The supply of students from different residential locations – in state, other U.S. states, and international – with sufficient academic and financial wherewithal to enroll in a particular public university limits how that university can adjust along these margins, while state-level politics constrain both increases in in-state tuition and decreases in in-state student representation.

Public universities value out-of-state students (U.S. or foreign) for at least two reasons. First, out-of-state students pay higher tuition charges for enrollment than their in-state peers, generating revenues for instructional expenditures for all students. Second, out-of-state students may increase the pool of high-ability peers, which is an important input to the university production function (Winston and Zimmerman, 2004; Groen and White, 2004; Rothschild and

[1] Constant dollars represented in 2014 units, using the Higher Education Price Index deflator.

White, 1995). An optimizing public university would aim to enroll out-of-state students to the point where marginal benefits are equal to marginal costs.

The broad hypothesis presented in this paper is that cuts in state appropriations have led public universities to change the composition of their student bodies by enrolling greater proportions of students who pay full-tuition. These public universities have disproportionately attracted foreign students in recent years as a reflection of their relatively plentiful supply driven by dramatic changes in educational attainment and family incomes in countries like China. In turn, the growth of foreign students may lead to declines in the representation of native students, even in the context of a model where the representation of in-state students is included in the university's objective function. We present empirical evidence consistent with this hypothesis and describe the mechanism in the context of a model of public university behavior.

Factors affecting the enrollment of out-of-state students in a public university include their capacity to pay the tuition and fees, their academic qualifications for admission, and their expected net returns compared to alternative options such as a private institution or a public university in their state or country of residence. The flow of college students across state lines has changed only modestly in the last decade: the share of first-time students attending four-year college out-of-state fell very modestly from 24.2% in 2000 to 23.9% in 2012 while the share of these students who attend public institutions stayed nearly constant at about 39%.[2] However, the number of foreign students enrolled in U.S. colleges and universities at the undergraduate level has increased 161% since the beginning of the 21st century, rising from 288,161 students in

[2] Authors' tabulations using the Integrated Postsecondary Education Data System (IPEDS) Residence & Migration Survey conducted by the Department of Education's National Center for Education Statistics (NCES).

fall 2000 to 482,203 in 2013, with more than two-thirds of this increase occurring at public universities.[3]

Our analyses show that decreases in state appropriations have had a large positive association with foreign undergraduate enrollment in the recent period. The association between appropriations changes and foreign enrollment is generally larger than the association with out-of-state domestic enrollment, which is consistent with the 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. Using an instrumental variable strategy which exploits changes in higher education funding at the state level, we estimate that a 10% reduction in state appropriations is associated with an average increase in foreign enrollment of 12% at public research 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. We find that changes that in the number of foreign students are associated with declines in-state students at some research public institutions, particular those that are likely to be the most resource-intensive.

The first section outlines 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 of the study 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 places the results in context.

[3] Authors' tabulations from the IPEDS Fall Enrollment Survey.

Section 1. Institutional Context and Empirical Motivation

U.S. Public Higher Education

In the U.S., public universities are distinguished by their scale, scope, and funding structure (Goldin and Katz, 1999). Although the U.S. has more private than public four-year colleges and universities, about 63% of all undergraduate degrees are awarded by public universities. Public universities serve a range of constituencies including undergraduate students, graduate students and professional students while also producing both applied and basic research innovations, which may benefit local industry. Organized and governed at the state level, public universities have a mandate to provide collegiate opportunities to in-state students, which is usually manifested in below-cost tuition rates and preferential treatment in admissions. Examples of the tuition for in-state versus out-of-state students at three selective public institutions in the 2014-15 academic year include: $13,208 (in-state) vs. $42,394 (out-of-state) at the University of Virginia, $13,486 vs. $41,906 at the University of Michigan and $12,972 vs. $35,852 for the University of California-Berkeley. Notably, the out-of-state tuition charges at these institutions approach those of similarly selective private institutions.

Public colleges and universities in the U.S. vary widely in terms of their resources and the extent to which they compete in national (or international markets) for students and faculty. Of the 60 U.S. universities that form the American Association of Universities (AAU), a long-standing organization of leading research universities, 34 are public universities. And, of the 50 international institutions rated highest in terms of research productivity by the Shanghai Rankings, 33 are located in the U.S., and 17 of these are public universities. In terms of the quality of undergraduate education, five public universities typically appear among the top-30

undergraduate colleges and universities in the U.S.[4] While some research universities enroll students from across the nation and the world, the majority of public colleges and universities draw students primarily from local or regional markets.

Within states, there is considerable stratification among public colleges and universities, with variation by size, selectivity, academic resources, and research activity, which is often by design (Sallee, Resch, and Courant, 2008). Typically, each state has at least one institution – often called the "flagship" – that has more research activity, is more selective in its admissions, and has greater levels of resources per student than other institutions in the state. While some states have several research universities that award doctorate degrees and receive considerable funds for research, states post-secondary systems typically include public colleges and universities that have modest (or no) research activity and focus on degrees below the doctorate level. Our analysis recognizes this stratification among public universities and we demonstrate both theoretically and empirically how a university's market position affects its prospects for adjusting to changes in appropriations by altering the level and composition of enrollment.

Funding U.S. Public Higher Education

The primary sources of funds for instructional expenditures at public universities are state appropriations and tuition revenues, with more modest resources emanating 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 state appropriations per full-time equivalent (FTE) student at public colleges and universities over the last 30 years. In

[4] The University of California Berkeley, UCLA, University of Michigan-Ann Arbor, University of Virginia and University of North Carolina-Chapel Hill are in the top-30 universities ranked by U.S. News and World Report.

aggregate, we see the dramatic decline from about $12,000 per FTE in the mid-1980s to less than $7,000 per FTE in the most recent year. What is visible is a secular decline with clear downward cycles following recessions in 1990, 2001, and 2008.

The combination of the increasing commitments for states to match federal spending on programs, especially entitlement programs, and the rising volatility of tax revenues in the last two decades have likely diminished states' capacity to fund higher education, particularly during cyclical economic downturns. Kane, Orszag and Apostolov (2005) show how state matching incentives for federal programs like Medicaid may crowd out funding of higher education. In turn, increased state commitments to entitlement programs like Medicaid exacerbate the impact of cyclical contractions on the higher education sector because revenue shortfalls must be absorbed in the 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.

It is these state-level fiscal conditions that largely determine the variation over time in appropriations at the university level. Many states follow rule-based approaches to allocate the budget pool available for higher education to institutions based on either the prior-year distributions adjusted for enrollment changes or formula-based approaches which account for direct costs and the number of enrolled students, with some states making further adjustments for performance measures; see Bell (2008) for a detailed discussion of the basic state funding models for higher education.

The decline in constant dollar state appropriations led to a marked increase in the share of public universities' total educational revenues covered by net tuition revenue, a share that rose from 29.4% in 2001 to 43.3% in 2011 (Bowen, 2012). Tuition and fees have risen at a much

greater rate in recent years for in-state students at public universities than for students at private institutions. For example, between 2008-09 and 2015-16, inflation-adjusted tuition and fees increased by about 20% at private four-year institutions and about 31% at public four-year institutions (College Board, *Trends in College Pricing*, 2015). States with the most severe economic downturns in the 2008 recession were among those that raised tuition the most, with in-state tuition increases greatest at the flagship and more selective institutions within each state (Barr and Turner, 2012). While lawmakers generally have acknowledged the need for in-state tuition increases at public universities in the face of steep appropriations cuts, they have also exerted strong political pressure to limit the rate of these increases.[5] Public universities have also increased out-of-state tuition levels in recent years – about 12% in real terms from 2009 to 2014 (College Board 2015) – with increases tempered by the marketplace alternatives available to out-of-state students among both private and other public universities.[6]

Beyond increasing revenues through raising tuition rates, some public universities may strive to increase the proportion of their student body that pays the full out-of-state tuition rate. 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." Another story in the *Chronicle of Higher Education* (Hoover and Keller, 2011) describes an "out-of-state gold rush" with admissions officers at public universities increasingly "hustling for business" in new

[5] 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)

[6] To illustrate, out-of-state tuition levels for 2014-15 for the University of Michigan ($41,906) and the University of Virginia ($42,394) now approach levels charged by private universities like Georgetown ($46,744) and Vanderbilt ($43,838).

full-fare markets. Still, it is important to underscore that only public universities that can compete with potential out-of-state students' best options in terms of price and quality have the capacity to raise overall revenues by increasing the proportion of full-tuition-paying enrollees.

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 out-of-state domestic students may come with costs along the margins of tuition revenue or student quality. That is, universities must either offer tuition discounts – merit aid or need-based financial aid – to attract academically well-qualified out-of-state students, or they must sacrifice academic qualifications to attract full-pay students.[7]

It seems very likely that the supply of well-qualified students from abroad is more elastic, and has become increasingly so as incomes in emerging economies have risen. This elastic supply would allow some public universities to use foreign enrollment as an important tool in recovering lost state appropriations while maintaining admissions criteria.

Supply of Students to U.S. Public Universities

In-State Students

State trends in the number of high school graduates and potential college-age students vary widely. Over the last half-century, some states have experienced significant declines while other states have experienced substantial increases in the college-age population. For example, from 1970 to 2004, college-age populations declined in Iowa (-22%), Indiana (-13%), Ohio (-

[7] Quoted in the *Chronicle of Higher Education*, Indiana University Professor Don Hossler notes: "There cannot possibly be enough students with the means 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).

18%), and Michigan (-15%), while they increased substantially in Florida (+99%), Texas (+56%), California (+42%) and Georgia (+41%).[8]

States that have experienced declines in the number of potential in-state students over time have particularly strong incentives to draw students 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, which 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 have excess capacity.

Domestic Out-of-State Students at Public Universities

Public universities also vary in the extent to which they draw domestic students from other states. For example, domestic out-of-state students comprise less than 5% of total domestic enrollment at the University of California-Davis, the University of California-Irvine, and Texas A & M, while they comprise more than 35% of domestic enrollment at the University of Michigan-Ann Arbor, the University of Colorado Boulder, the University of Oregon, and the University of Iowa. Public universities that can compete with the top private universities draw many students from out-of-state. Note, however, that UCLA and the University of California at Berkeley have been exceptions to this norm until recently. Because out-of-state tuition exceeds in-state tuition and few public universities meet full financial need with grant funding, domestic out-of-state students attending public universities tend to be more affluent as a group than in-

[8] Data reflect the population age 18 as reported by the Census.

state students. Also, domestic out-of-state students attending public institutions tend to originate from states with a limited supply of high-quality public options (Bound, Hershbein and Long 2009).

Foreign Students

The number of foreign college students in the United States has increased markedly since 2000, with a particularly steep increase from 2006 to 2013, during which time enrollment of foreign undergraduate students rose 50%, from 321,279 to 482,203.[9] The supply of students from abroad to U.S. higher education institutions is plausibly a function of home country education markets and labor markets (Rosenzweig, 2006). Four broad factors affecting supply from abroad to U.S. public universities: 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, in cases where employment opportunities are greater in the U.S. than in the origin country, the extent to which study in the U.S. provides an "option value" to the U.S. labor market.[10]

[9] As a point of comparison, enrollment of foreign graduate students rose 30%, from 274,790 to 356,897 over the 2006 to 2013 interval. Authors' tabulations IPEDS Fall Enrollment Survey.

[10] 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 finds that the primary determinant of foreign student enrollment is consistent with the migration model, implying 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.

Capacity to pay for higher education is a potent factor in the flow of students to the U.S. at the undergraduate level. Unlike foreign doctoral students, who commonly receive full support in the forms of fellowships, teaching assistantships, and research awards, foreign undergraduates are generally expected to make full tuition payments. For this reason, trends in the flow of students at the undergraduate and graduate levels tend to differ from each other and by country of origin. For countries undergoing rapid economic expansion over the past two decades, such as China and India, the growth in foreign enrollment for U.S. graduate education preceded the growth for undergraduate education, likely because U.S. institutions offer substantial financial aid for graduate study, particularly in PhD science programs.

The four countries that have contributed most to the dramatic growth in U.S. undergraduate enrollment of foreign students since the early 1990s are China, Saudi Arabia, India and South Korea as shown in Figure 2. In academic year 2013-14, these four countries accounted for more than 50% of undergraduate enrollment of foreign students, with China alone accounting for 30%. In fact, the growth in undergraduate students from China – from around 8,000 students in 2003-04 to more than 111,000 in 2013-14 – accounts for 90% of the total increase in foreign undergraduates over this decade. [11] Few households in the Chinese population could afford undergraduate education in the U.S. until the late 1990s, when China began to experience rapid economic growth.

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,

[11] 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-abdulla-hstages/pages/default.aspx).

participation in secondary education rose steeply, with the number of students graduating from non-vocational secondary institutions in China increasing from around 3 million in 2000 to more than 8 million in 2013 (China Statistical Year Book, 2013). Secondly, GDP per capita in current US$ increased more than six-fold during this period, from $954 in 2000 to $6,264 in 2012 (World Bank Development Indicators). This change reflects both real GDP growth in China as well as an appreciation of the Yuan, which made American education cheaper for Chinese students. We calculate that while less than 0.005% of Chinese families had incomes equal to the average charged for out-of-state tuition and room and board by U.S. public universities in the year 2000, by 2009 approximately 0.032% would have had such incomes – a growth that continues exponentially, as by 2013 more than 2% families are predicted to have such incomes.[12]

While some of the students from China studying in the U.S. are from very wealthy families (Liu, 2015; Higgins, 2013; Fischer, 2014), others have parents who invest a large share of household income into their children's education. Many parents in this generation have a single child, reflecting the one child policy in many parts of China, and with this constraint, parents concentrate their investments in the single child.

Even as post-secondary options have increased in China and other Asian countries, expansion in enrollment among their top-tier universities has been very limited. Indeed, the selectivity of top universities in India and China – measured by applicants relative to admissions

[12] Authors' calculations, based on income distribution data from the World Bank and average tuition, room and board charges for out-of-state students at public universities recorded in IPEDS. We derived the income distribution (assumed to be log-normal) following the approach of Pinkovskiy and Sala-i-Martin (2009). With the mean from GDP-per capita, we calibrate the standard deviation using income shares received by each quintile of the income distribution (available from the World Bank). Using the currency exchange rate, we convert to constant U.S. dollars and compute the expected share of households with incomes greater than the average public tuition, room and board for out-of-state students.

opportunities – is greater than for the most elite private universities in the U.S. [13] These higher education supply constraints motivate foreign students to seek enrollment in the U.S. and other countries with well-developed higher education sectors such as the U.K. and Australia.

Two broad points motivate our theoretical and empirical analyses of U.S. public university enrollment adjustments to changes in state appropriations. 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. Second, while per capita incomes have been stagnant and the number of high school graduates has increased only modestly in the U.S., potential flows of foreign students to the U.S. have increased markedly.

Examples: Michigan and California

Before turning to our theoretical model, we look at enrollment trends in public universities in Michigan and California, which illustrate differences in market positions and enrollment patterns among public research universities.

Like many states, Michigan has a stratified set of public colleges and universities with 18 four-year degree-granting institutions, in addition to a large network of community colleges. While the University of Michigan (U-M) and Michigan State University (MSU) – both AAU members – are research universities with nationally recognized doctorate programs, U-M is more selective at the undergraduate level and generally ranked ahead of MSU in national rankings of undergraduate universities. Figure 4 shows trends, 1996-2013, in first-time student

[13] 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).

undergraduate enrollments by foreign, (domestic) out-of-state, and in-state residency for U-M, MSU, and Eastern Michigan University (EMU), a smaller, more regionally concentrated public university that offers PhD-level education in only three programs and has a much smaller research portfolio. U-M (Panel A, right) shows little change in either out-of-state or foreign enrollments over the period, with just a modest uptick in out-of-state enrollment after 2007. MSU (Panel B, right) shows a dramatic rise in foreign enrollment 2007 to 2013, but only modest increases in out-of-state enrollment. Finally, EMU (Panel C, right), where the vast majority of students are from in-state, shows no evidence of a rise in foreign enrollment. [14]

California, like Michigan, has a stratified network of public universities and colleges. However, until relatively recently, California was distinguished from Michigan by a stronger tradition of support for higher education from state appropriations – manifest in a proportionately larger ratio of state appropriations to instructional expenditures. The result of this very low in-state tuition was that even the most highly ranked research universities in the University of California system, like UC-Berkeley and UCLA, had small out-of-state enrollments. However, from 2007 to 2013, nominal state appropriations for higher education in California fell from more than $11 billion to about $9.5 billion, even as total enrollment increased. This decline is associated with a change in enrollment patterns at California universities. At UC-Berkeley, the rise in out-of-state domestic students is actually somewhat larger than the rise in foreign students, while at UC-Davis, which is also an AAU research university but less selective than UC-Berkeley, the rise in foreign students far exceeds the rise in out-of-state students. Across the California state universities, out-of-state domestic enrollment is miniscule (less than 400

[14] While roughly 15% of students at EMU are from out of state, depending on the year, two-thirds or more of these students are from Ohio, which has a reciprocal agreement with EMU, thus not representing a source of increased revenue.

students), while enrollment of foreign students is modest (less than 5% of total first-time enrollment) even with a jump between 2012 and 2013.

The differential changes in enrollment patterns in these two states by type of institution can be interpreted in the context of a stratified market. The most selective public institutions are able to attract students from out-of-state and abroad similarly to similarly selective private institutions. Public universities that are well-regarded as research universities but outside this highly-ranked tier often have difficulty in attracting full-pay students from other states but are likely to be successful in drawing in foreign students and have a particular incentive to do so in response to appropriations declines. Finally, there is a tier of public colleges and universities operating in a primarily local or regional market that is unlikely to be able to offer foreign students educational opportunities at a sufficiently low-price, high-quality combination to attract students at typical out-of-state prices.

Section 2. Theoretical Framework

To guide our interpretation of our empirical work we develop a simple theoretical framework that describes the behavior of public universities and state legislators, with the different objective functions of the state legislatures and the university administrators captured in a principal-agent problem.[15] State legislatures focus on the number of in-state students enrolled in the public university. University administrators have an objective function focused on the quality of the education provided by the public university, which depends on both purchased resources and the academic ability of the student body.[16] State legislatures offer state

[16] This paper relates to Epple et al. (2006) and Epple et al. (2013), which model enrollment decision of public and private universities. Different from the existing literature, we describe the relationship between universities and state

appropriations as a compensation scheme, which creates incentives for public universities to enroll more in-state students. Our model abstracts from specific mechanisms states may use to enforce such schemes. We treat in-state and out-of-state tuition as exogenous. It is reasonable to think that out-of-state tuition is set by the market because state universities have to set these tuitions to be competitive with the private sector. In contrast, it is natural to assume that State Universities have some market power, and, as such, have an incentive to raise in-state tuition in response to declining appropriations. To keep things simple, we abstract from this possibility in the model we present bellow. However, in Appendix 2, we expand this model allowing in-state tuition to be endogenous.

The model predicts that public universities enroll foreign students to the extent that they pay higher tuition, effectively increasing the educational subsidy of in-state students. Another prediction of the model is that when state appropriations decline, public universities are more likely to admit foreign students because the marginal benefit of adding foreign students (and associated tuition revenues) increases.

2.1 Model Framework

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

University's Objective Function

The public university's objective of maximizing the quality of education depends on the academic abilities of enrolled students and the purchase of educational resources I, with the latter

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legislators as a principal-agent problem and incorporate foreign enrollment decisions to the university's set of choices.

afforded through tuition revenues and appropriations from the state. 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. The function $q(.)$ is also twice differentiable, and increasing in both arguments.

The maximization problem of university administrators is given by:

$$max_{I,K_s,K_{o,}\,K_{f,}} q(I, \theta)$$

where, in addition to choosing the resource investment I, the administration determines student quality through the admission and enrollment of students, where K_s , K_o , K_f are the number of the enrolled in-state, out-of-state domestic, and foreign students, respectively.

Supply of Students

We assume that a university faces a given supply of applicants that are heterogeneous in terms of their ability. 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 an increase in enrollment of student of type *j*:

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

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

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

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 $\varphi(.)$, which represents the costs associated with expanding enrollment, is strictly increasing and convex in all arguments. We define the marginal costs associated with increases in K_j :

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

The university also faces a convex cost function for educational investments – costs that affect the quality of education provided to students.

University Revenue Function

Public university revenue comes from tuition revenue and non-tuition sources like appropriations. 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 domestic students. The university's revenue is given by:

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

where $R(.)$ denotes the non-tuition income of the public university. In our framework, it corresponds to state appropriations $R(K_s)$, which represent a contract set by the state legislature as a function of the enrollment of in-state students. The transfer from the state (non-tuition revenue) received by a university is an increasing function of the number of in-state students the university enrolls.

It follows that the university budget constraint (or individual rationality constraint in the context of the principal agent model) is given by:

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

2.2 The Optimization Problem of a Public University

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

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

Subject to the budget constraint:

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

And non-negativity 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):[17]

a) FOC with respect to in-state students: $R'(K_s) + p_s = \varphi_s - \frac{q_\theta \theta_s}{\lambda}$

b) FOC with respect to out-of-state students: $p_o = \varphi_o - \frac{q_\theta \theta_o}{\lambda}$

c) FOC with respect to foreign students: $p_o = \varphi_f - \frac{q_\theta \theta_f}{\lambda}$

d) FOC with respect to investment in education: $\frac{q_I}{\lambda} = \rho I$

where $R'(K_s)$ is the derivative of the state appropriations contract between the university and the state with respect to K_s, which is a positive function for every K_s. q_θ, and q_I are the first

[17] We only evaluate interior solutions for the university problem.

derivate of the function $q(.)$ with respect to θ, and I respectively, and λ is the Lagrangian multiplier associated with the budget constraint.

The FOCs 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 in-state students is the tuition they pay as well as the increase in state appropriations associated with higher in-state enrollment. The marginal cost is the expense of enrolling an additional in-state student as well as the monetized cost of the (potential) decrease in the quality of the current student body associated with expanding the enrollment of in-state students. A public university enrolls in-state students until their marginal benefit is equal to their marginal cost. State legislators will take this behavior in consideration when setting their state appropriations contract.
- *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 expense associated with their enrollment as well as the monetized cost of the (potential) decrease in the quality of the student body associated with expanding enrollment of out-of-state and foreign students.
- *Resource investment*: The marginal benefit of educational resource investment is the monetized benefit of an increase in the quality of education provided by the university. The marginal cost is the expense associated with the investment.

Overall, a public university enrolls in-state, out-of-state, and foreign students until their marginal benefit is equal to their marginal cost. As a result, the relative tuition, marginal costs, state appropriations contract, 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 at a public university.

2.3 State Legislature's Decision Problem

State legislatures are assumed to maximize their objective function through the number of in-state students enrolled in a public university as well as their capacity to provide other public goods to the rest of the population (g). We assume that state legislatures have a Cobb-Douglas preference over these two goods: $K_s^{\beta} g^{1-\beta}$, where β is the state preference for higher education, which is greater than zero and smaller than one. In reality, state legislatures might care about the quality of education provided by their public universities, but the extreme case presented here highlights the conflict of interest we want to stress with the model.

State legislatures have a budget constraint: $Y = R + p_g g$, where Y is the exogenous state (disposable) revenue, p_g is the price of the public good provided by the state, and R is the level of state appropriations to public universities. The state legislature chooses a state appropriation contract $R(.)$ and a provision of a public good g:

$$max_{R(),g} K_s^{\beta} g^{1-\beta}$$

subject to the budget constraint:

$$Y = R + p_g g.$$

When making their appropriation decisions, state legislatures must consider the optimal strategy of university administrators, which is given by the incentive compatibility constraint of university:

$$R'(K_s) + p_s = \varphi_s - \frac{q_\theta \theta_s}{\lambda}$$

In addition, state legislators must consider the university's operating constraints, which are given by their budget constraint (individual rationality constraint):

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

Intuitively, state legislatures must balance benefits and costs to both the state and the university when deciding appropriations. State legislatures know the optimizing goals and budget restrictions of university administrators. If they offer more generous appropriations, they create the incentives for university administrators to enroll more in-state students. But because state legislators must also use state revenues to provide other public goods and services (e.g., roads, elementary and secondary education), their optimal state appropriation contract will balance the marginal benefit of the additional in-state enrollment with the marginal cost of having fewer resources for the other public expenditures.

2.4 Parametric Assumptions and the Optimal State Appropriation Contract

To derive a closed-form solution for the principal agent model, we make some parametric assumptions.

State Appropriations Contract

First, we focus on contracts in which the state appropriation is a fixed-piece rate of in-state enrollment: $R(K_s) = \gamma K_s$. Piece-rate contracts are simple to analyze, create uniform incentives, and are observed in many real-world settings. In this set up, the state legislature's contract is defined by the choice of the parameter γ.

University's Objective Function

We assume that educational investment and mean student academic ability are perfect substitutes: $q = \alpha I + \theta$. In other words, to maximize educational quality, the

university can perfectly substitute a lower quality student body with higher investments in education.[18]

Supply of Students

We assume that the marginal change in the student body ability associated with the expansion of enrollment is negative for each j, such that: $\theta_j < 0$ 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 in terms of academic ability. This assumption is consistent with a university ranking their applicants by ability and admitting the highest ability applicants first.[19]

In addition, we assume that $d\theta_f / dK_f = 0$, and $d\theta_j / dK_j < 0$ *for* $j \neq f$. This assumption is consistent with an elastic supply of foreigners, which implies that the ability of the marginal foreign student changes relatively little as the university expands foreign enrollment. We also define the constant $\mu_j \equiv (-1)\, d\theta_j/dK_j$ *for* $j \neq f$.

Cost Function

We assume that the marginal cost of enrolling 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.[20]

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[18] As it will be clear later, this functional form assumption will imply a quasi-linear maximization problem of the university administrators with respect to foreign enrollment.

[19] 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.

[20] 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.

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 Generator Students

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

$$p_o - c > 0 = p_s - c$$

This condition implies that foreign and out-state students are net revenue generators to the university, with their tuition revenues used to cover their marginal costs as well as to subsidize the education of in-state students and increase educational investment. To simplify our calculations and without loss of generality, we also assume that in-state tuition equals the marginal cost of enrolling an additional in-state student.[21] Under this condition, university administrators will enroll in-state students until the marginal benefit of increasing state appropriations is equal to the marginal cost of decreasing student body quality.

2.4.1 Solution

We will focus our analysis on interior solutions for the maximization problem of the university administrators. From the first-order condition with respect to foreign student enrollment, the value of the Lagrangian multiplier is:

[21] In Appendix 2, we relax this assumption while making in-state tuitions endogenous.

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

The constant Lagrangian multiplier is a direct implication of the quasi-linear functional form assumption on the maximization problem of the university with respect to foreign enrollment.

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 foreign 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 matched to the university. The intuition is that foreign 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.

With these assumptions, the incentive compatibility constraint of university administrators can be expressed as: $K_s^* = \frac{\lambda^*}{\mu_s}\gamma$ where λ^* is the Lagrangian multiplier of the university administrators' maximization problem derived above. In this setup, the optimal choice of in-state enrollment of university administrators is positively related to the monetary

compensation they receive from the state to enroll an additional in-state student and negatively correlated with the decrease in the student body quality associated with expanding in-state enrollment.[22]

Finally, we derive an expression for the enrollment of foreign students:

$$K_f^* = \frac{p_o - c}{2\rho}\left(\frac{\alpha}{\theta_f}\right)^2 + \frac{\theta_f}{\mu_0} - \frac{R(K_s^*)}{p_o - c}$$

This expression provides some interesting insight. 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 enrolling foreign students increases.

Optimal State Appropriations Contracts

Substituting the optimal in-state enrollment expression into the state legislature's maximization problem yields:

$$max_{\gamma,g}\left(\frac{\lambda^*}{\mu_s}\gamma\right)^{\beta} g^{1-\beta}$$

subject to a budget constraint:[23]

$$Y = \frac{\lambda^*}{\mu_s}\gamma^2 + p_g g$$

[22] It is also indirectly related to the quality of foreign students and the out-of-state tuition through λ^*.
[23] In this quasi-linear set-up, state legislator might ignore the individual rationality constraint as universities will adjust foreign enrollment to balance their budget.

From the FOC, we obtain the optimal piece-rate parameter of the optimal state appropriations contract:

$$\gamma^* = \left(\frac{\beta}{2-\beta}\frac{\mu_s}{\lambda^*}\,Y\right)^{\frac{1}{2}}$$

Substituting this expression in the state appropriations contract, we can derive the equilibrium state appropriations as a function of the parameters of the model:

$$R^* = \frac{\beta}{2-\beta}Y$$

which is an increasing function of exogenous state (disposable) revenues and the state legislature's preference for higher education. The intuition is that, in equilibrium, states spend more on higher education if they have higher revenues or if they have stronger preferences for higher education over other public goods.[24]

Equilibrium Enrollment

Using the expressions above and the incentive compatibility constraint of university administrators, we can derive the equilibrium in-state enrollment as a function of the parameters of the model:

$$K_s^* = \left(\frac{\lambda^*}{\mu_s}\,\frac{\beta}{2-\beta}Y\right)^{1/2}$$

which is an increasing function of exogenous state (disposable) revenues and a decreasing function of μ_s, which measures the decrease in quality of the student body associated with the marginal enrollment of an in-state student.[25] The intuition is that, in equilibrium, in-state enrollment is a function of both state resources and the supply of in-state students. In other

[24] We explore this relationship empirically in a two-state least square estimation.
[25] It is also indirectly negatively related to the supply of foreign applicants through λ*.

words, if demand for higher education increases within a state, the university will receive higher quality in-state applicants and therefore face a lower value of μ_s. Furthermore, if state revenues rise, the state will increase appropriations to the university, which will respond by enrolling more in-state students.

Using the optimal appropriation contracts, we can also derive the equilibrium foreign enrollment as a function of the parameters of the model:

$$K_f^* = \frac{p_o - c}{2\rho}\left(\frac{\alpha}{\theta_f}\right)^2 + \frac{\theta_f}{\mu_0} - \frac{1}{(p_o - c)}\left(\frac{\beta}{2-\beta}Y\right)$$

which is an increasing function of the quality of marginal foreign applicants and a decreasing function of the exogenous state (disposable) revenues.[26]

Comparative Statics

Based on the enrollment expressions derived above, the model predicts that in-state enrollment is positively related to state appropriations and foreign enrollment is negatively related to state appropriations. The exogenous driver of state appropriations is the state (disposable) revenue Y. With more revenue, the state legislature can offer better appropriation contracts γ^* to universities, which translates to a higher marginal benefit of enrolling in-state students. Note that in the model, foreigners and in-state students are substitutes for a university as they generate revenue used in the purchase of educational resources. A better appropriation contract would make universities less dependent on the tuition paid by foreign students, which would lead to a decrease in foreign enrollment.

[26] Note that the parameter θ_f is negative.

In terms of the supply of foreign applicants, the parameter that defines the availability of foreign students to the university is the (negative) constant θ_f, which represents the decrease in student quality associated with expansion of foreign enrollment.[27] Increases in the supply of highly qualified foreign students would serve to decrease θ_f in magnitude, as the university can recruit better foreigners without affecting the quality of the student body much.

The result is that a decrease of θ_f in magnitude is associated with higher foreign enrollment and lower in-state enrollment. With better international applicants, universities can obtain more tuition revenues by increasing foreign enrollment without changing the quality of the student body much. Note also, that an increase in foreign applicants generates more tuition revenue to the university that leads to a higher I^*.

Finally, an increase in quality of foreign applicants would also affect how sensitive in-state enrollment is to changes in appropriations. Indeed, the model predicts that dK_s^*/dY is small when universities have access to better foreign applicants. The intuition is that schools with more access to foreign students will be less dependent on state-appropriations. As a result, in-state enrollment is less sensitive to the level of state appropriations than would be the case were it not for the availability of the foreign students.

Note that the same crowding out mechanism and other qualitative results hold in a model where the university's objective function depends both on in-state enrollment and quality of education, such as in the setup employed by Epple et al (2013). For example, in a setup where the university's objective function is $q(\theta, I)^{\sigma} K_s^{1-\sigma}$, the benefit of in-state enrollment comes from

[27] Note we assume that as a university expands the enrollment of any type of student, it necessarily decreases the quality of its student body.

the utility function rather than extra revenue associated with appropriations, but such model predicts the same adjustments mechanism as in the principal-agent framework.

It is worth emphasizing that, in the context of the above model, one expects to find declines in in-state enrollment in response to the increasing availability of highly qualified foreign students even though the university administrators care only about the quantity and quality of the education they are providing in-state students. Additionally, in the model, universities will respond to declines in state appropriations by enrolling fewer in-state and more foreign (or out of state) students. Such apparent "crowd out" effects will occur as long as university administrators value the quality of the education they are providing.

University Heterogeneity: Research vs Non-Research Universities

In the model above we describe the enrollment decision of a typical public university. Nonetheless, as will be clear in the empirical section, there are systematic differences across universities in the number of foreign students enrolled and in how foreign enrollment responds to appropriation shocks.

A way that our model can explain this heterogeneity is to account for systematic differences among universities in the supply of high-quality applicants.[28] In particular, we expect that very selective research universities, such as University of Michigan, have access to an elastic supply of high quality out-of-state and foreign applicants (θ_f and μ_0 are low in magnitude). As a result, our model predicts that very selective research universities have high out-of-state enrollment compared to foreign enrollment.

In the same way, we expect that less selective research universities, such as Michigan State University, have access to an elastic supply of high-quality foreign applicants, but face a

[28] The difference in supply of applicants can be driven by endowment income, which is ignored in this framework and affects university quality.

very rapid decrease in out-of-state applicant quality as they expand enrollment (low θ_f and high μ_0 are high in magnitude). Our model predicts that less selective research universities will have high foreign enrollment relative to out-of-state enrollment, and will adjust to appropriations shocks by increasing foreign enrollment.

Finally, we expect that non-research universities, such as Eastern Michigan University, have limited access to out-state and foreign student applicants (θ_f and μ_0 are large in magnitude). As a result, our model predicts that non-research universities might only recruit in-state students (non-interior solution) and decrease in-state enrollment as result of negative funding shocks, in the absence of changes in enrollment demand

Section 3. Empirical Strategy and Data Sources

3.1 Estimation Strategy

Our main regressions focus on the link between changes in state appropriations and first enrollment of in-state, out-of-state, and foreign students. In addition, we also study the effects of state appropriations on the 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 outcomes on appropriations, cohort size, and state economic conditions. Thus, observations are at the level of the university *(i)* and the year *(t)*. The primary specification is:

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

where y_{it} is the outcome of interest, App_{it} represents state appropriations, X_{it} are state-level time-varying controls, and γ_t and δ_i are year- and institution-specific fixed effects, respectively.

As described in our model, an important determinant of in-state, out-of-state, and foreign enrollment for a university is its potential supply of applicants. The purpose of the year fixed effects is to control for the overall increase in the supply of out-of-state and foreign applicants during the period of analysis. In addition, the year effects should control for overall changes in the demand for a college education. Thus our identification comes from changes to appropriations unique to the institution rather than overall secular economic changes. We also include Census estimates of the population at age 18 by state as a covariate in all regressions to control for shifts in the supply of in-state applicants. Evidence indicates that college-age populations strongly drive in-state enrollment patterns (Bound and Turner 2007).

Instrumental Variables Estimation

Though, for the most part, we rely on OLS estimation, we are ultimately interested in the causal effect of appropriation changes on enrollment patterns. There is reason to believe that after controlling for institution and year fixed effects, as well as the size of state college-age population, institution-specific changes in demand for particular universities would be partially accommodated by state legislatures through state appropriations. Indeed, as outlined by Bell (2008), the allocation of state funds to institutions often makes explicit considerations of enrollment levels. To the extent that this is true, this endogeneity will tend to bias β_1 upwards, against the effect we are hypothesizing, when the dependent variable is foreign enrollment.

To address potential endogeneity of appropriations at the institutional level, we also propose an instrumental variable estimation approach wherein we use the total state appropriations in a given state-year as an instrument for university-specific state appropriations. This instrument exploits the variations in appropriations driven by state-specific budget shocks

rather than university-specific preferences of the state legislators.[29] The identification assumption is that variation of total state appropriations is orthogonal to unobservable determinants of enrollment It also better represents the adjustment mechanisms derived in the model, where exogenous changes in state revenues drive changes in appropriations.

We believe our identification assumption is reasonable for several reasons. State appropriations to higher education are often viewed as the "balance wheel" of state budgets to the extent that state legislators decide the total state appropriations budget by seeing what is left after other spending priorities (Bell, 2008). Indeed, total state appropriations are determined after items with mandates or little discretion like Medicaid, transportation, K-12 and prisons are funded, with the allocation between institutions within the State then either determined by a formula or an appropriations subcommittee following historical norms. This interpretation is consistent with the literature which indicates that the main determinants of state appropriations are the cyclical pressures from federal programs with state-level matching features (e.g., Medicaid) as well as the political affiliations of the governor and the majority of the state legislators (Okunade 2004 and Kane, Orszag and Apostolov, 2005).

3.2 Data Sources

Data on annual enrollments, degrees conferred, and finance variables for each college and university are collected through several sources. First, as part of a long-standing federal data collection mandate, the Integrated Postsecondary Education Data System (IPEDS) collects annual data related to different university functions, including enrollment, finances, and degrees

[29] We also explored using total state revenues as instruments for university-specific appropriations. While the results are qualitative similar to using the state appropriations budget instrument, we find weaker first-stage results and therefore opt for the latter instrument.

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 viable and large pool of foreign born students considering undergraduate education in the U.S.

We also use data from the Fall Enrollment survey, which records enrollment by level and visa status for each post-secondary institution, distinguishing enrollment by first-time freshmen, all undergraduate students, and graduate students. We focus on first-time freshman enrollment and use the survey distinction between temporary visa holders and U.S. residents to record counts of "Temporary Residents" for each year of our analysis. By definition, any student holding a temporary visa is a foreign-born person who is "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-type ("student") visa.

To distinguish domestic students by in- or out-of-state status, we use data from the American Survey of Colleges (ASC), conducted annually by the College Board. While this source shares many data elements with the IPEDS data collection, the ASC has more detail on the characteristics of admitted and matriculating students.[30] In order to reduce the incidence of missing data, we complement our dataset with enrollment information from the Common Dataset Initiative and the University California System, when this information was missing in the ASC.

In addition, IPEDS collects detailed financial information for post-secondary institutions, including revenue from different sources and expenditures, from which we derive data on

[30] 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.

revenues/expenditures tied to instruction. For tuition measures, we make use of "Total Tuition Revenue" – the accounting measure of tuition charged to students at all levels – along with the "sticker" prices charged to in-state and out-of-state students at the undergraduate levels. We complement the state appropriations data using the Universities Financial Statements (Annual Financial Reports), when this information was missing on IPEDS.

We focus our analysis on public research universities, institutions distinguished by the scope and scale of their activities, including doctoral programs, graduate professional schools, and substantial portfolios of funded research.[31] As we show, public post-secondary institutions operating outside this sector are much more limited in their capacity to draw foreign students. Among public institutions of higher education, it is the research universities that are most likely to accommodate increased student demand from abroad. Table 1 presents summary statistics for enrollment, appropriations and tuition by type of institution for academic years beginning in 2007 and 2012. The sample includes both public research universities (those with sizeable federal research funding) and the broader group of non-research public colleges and universities. Statistics are also presented for two subsets of all research universities: those designated as state "flagship" universities and those that are AAU members. As shown, on average, non-research four-year institutions enrolled a small number of foreign students in 2007 and added little to that sector by 2012, even as enrollment increased overall. Also shown is the shift in revenue sources from appropriations to tuition revenue: for research universities, appropriations relative to tuition revenue declined from a ratio of 1.28 to 0.75 over the period; while at non-research universities, the ratio falls from 0.74 to 0.47.

[31] Specifically, these are 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.

Section 4. Empirical Results

4.1 Effects of State Appropriations on Enrollment

Our first empirical test is to examine the effect of variation in state appropriations on first-time undergraduate enrollments of in-state, out-of-state, and foreign students. We focus on the period 1996 to 2012 and include institution and year fixed effects in all specifications. Table 2 shows both the OLS and IV results for all public research and non-research universities, with "Flagship" and "AAU" designations for subsets of research universities (as described for Table 1, above). Table 2A presents results with the enrollment outcomes in logs while Table 2B reports the results with this outcome in levels. The distinction between foreign students and domestic students, both in-state and out-of-state, is marked in the enrollment response to appropriations changes.

For foreign students during this interval, we find a consistent negative relationship between appropriations and enrollment at public research universities in both the OLS and IV regressions. In the OLS specification, we estimate that a 10% reduction in state appropriations predicts an increase in foreign enrollment of 7.5% at flagship universities, 7.92% at AAU institutions, and 6.2% at the more inclusive group of all research universities, while the estimate is indistinguishable from zero outside the research sector of public institutions.

Turning to the IV specification, the first-stage F statistic on the instrumental variable in these specifications is quite strong and the associated impacts of appropriations shocks on enrollment sustained. The point estimates for the effect of appropriations shocks on foreign enrollment are yet larger in magnitude (though the differences between the OLS and IV estimates are not statistically significant), with a 10% decrease in appropriations tied to a 12% increase in foreign enrollment for all research universities, and a 17% increase for flagships and

AAU institutions. This finding is consistent with the prediction of our model: when state appropriations decline, public universities are more likely to admit foreign students because the marginal benefit of adding foreign students (and associated tuition revenues) increases. For non-research colleges and universities (shown in the final column), we continue to estimate essentially no link between changes in state appropriations and foreign student enrollment, which is consistent with the expectation that non-research universities tend to be much more locally focused than the research universities, and have limited capacity to attract foreign students.

For out-of-state domestic students, variation in state appropriations has essentially no effect on first-time undergraduate enrollment for any of the institutions in both the IV and OLS specifications. 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 (Panel C of Table 2A), 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 research universities in the OLS specification. For the non-research universities, the link between appropriations and in-state enrollment is positive, though small in OLS (a 10% increase in appropriations linked to about a 1.2% increase in first-time enrollment). [32] Note that this could just reflect some degree of reverse causality because universities might be compensated for enrolling more in-state students. We indeed do not find any significant relation between in-state enrollment and state appropriation in any of the IV specifications.

[32] Not surprisingly, changes in cohort size – the population age 18 from in-state – lead to less than proportional changes in enrollment at the research universities and about 1:1 adjustment in the non-research universities, where supply is expected to be much more elastic (Bound and Turner 2007).

Estimates of enrollment effects, represented in Table 2 should be thought of as specific to the most recent interval in which the supply of foreign undergraduate students is ample. 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 was likely more limited. With enrollment presented in levels in Table 2B, we see qualitatively similar results in the form of foreign enrollment increases in response to declines in state appropriations, with foreign enrollment rising by an average of about 28 students in response to a 10% decline in appropriations at research universities and an average of 37 students for the same appropriations decline at flagship universities. In the Appendix of this paper, we present robustness checks for the negative relationship between state appropriations and foreign enrollment, which include adding university specific time trends and controlling for state unemployment to the models reported in Table 2.

4.2 The Link Between Foreign Enrollment and Domestic Enrollment

It is natural to ask whether foreign students are "crowding out" domestic students, particularly in-state students. Our model suggests that as long as universities care about the quality of the education they provide students, the increased availability of capable foreign students who are willing to pay out of state tuitions, will induce schools to recruit these students at the cost of enrolling in-state students. In addition the model suggest that schools with access to capable foreign students will respond to budget cuts by increasing the recruitment of foreign students again at the expense of domestic in-state students.

While we have emphasized that we would expect declines in appropriations to have a larger effect on foreign as opposed to out-of-state enrollments, given the far more elastic supply of the former, there is little reason to think the direct effect of an increase in foreign enrollment would differ from an increase in out-of-state enrollment. As an empirical matter, few universities experience substantial changes in out-of-state enrollment over our period of observation.

To be sure, the endogeneity of foreign and domestic out-of-state enrollment mitigates against strong causal interpretations of regressions of in-state enrollment on foreign enrollment.[33] Nevertheless, the empirical association between in-state enrollment levels and enrollment levels of foreign and out-of-students presented in Table 3 provides evidence of negative association between changes in foreign and in state enrolment at the research intensive universities. On average at the research universities each additional foreign student is associated with a decline of about 0.55 in state students. This effect is concentrated at the AAU universities, while not apparent in the other classifications of research universities or the non-research public universities.[34]

4.3 State Appropriations and Educational Expenditures

Changes in state appropriations directly affect university budget constraints and, absent other channels of adjustment in university revenues, declines in state appropriations would have a negative effect on measures of expenditures – particularly those related to undergraduate

[33] Ideally, we would be able to present IV estimates of the effect of total out-of-state enrollment on in-state enrollment; however, we are unable to present credible instruments with sufficient power for both foreign and out-of-state domestic enrollment.

[34] In regression results not included in the table, we estimate the parallel coefficient associated with foreign students as 0.718 (0.760).

education. As we discuss below, the other potential margins for adjustment include increasing tuition charges directly or increasing the proportion of enrolled students paying the higher 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 present baseline results from regressions of educational expenditures on state appropriations, along with institution and year fixed effects, for each category of public university. If universities did not adjust their revenue sources to make up for 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 changes would have the most modest impact on expenditures at 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 outcomes for two measures of instructional expenditures: total expenditures for instruction (top panel) and for salaries and wages (bottom panel). For all research universities, a 10% decrease in state appropriations aligns with about a 1.5% decrease in instructional expenditures and a 1.8% decrease in salaries. Effects for the flagship universities are similar in magnitude, though the confidence intervals are somewhat larger. Estimated effects for the AAU universities are indistinguishable from zero, suggesting that these resource-intensive institutions are able to find other sources of support for instructional expenditures in the face of appropriations shocks. Notably, non-research institutions demonstrate the greatest expenditure elasticity to appropriations shocks.

Table 5 presents results for how appropriations shocks are reflected in two non-instructional expenditure categories: academic and research support services.[35] Expenditures for academic support services – which include spending on libraries, administration, and IT services – are fairly sensitive to changes in appropriations, falling about 2.4% (AAU) to 4.0% (non-research universities) in association with a 10% decline in state appropriations. As one might expect, research activities, which tend to be funded primarily from revenue streams other than state appropriations, are not particularly sensitive to appropriations shocks.

Changes in state appropriations at the institutional level are directly related to core instructional expenditure categories, particularly outside the public research university sector. Among research universities, the AAU institutions are best able to insulate expenditure categories from appropriations changes. The offset between appropriations and dollars spent on instruction depends on the appropriations share of revenues supporting the undergraduate experience, which decreased over the interval for both research and non-research universities (see Table 1). Using 0.5 as an approximate benchmark for the appropriations share, we still find that appropriations shocks generated spending shocks that were far less than proportional, though relatively larger outside the research university sector.

4.4 State Appropriations and Tuition Revenues

Looking at the period-to-period changes in tuition and appropriations between 2007 to 2012, depicted in Figure 5, reveals a strong negative link between changes in tuition revenues (from all enrollment residencies) and state appropriations, with a simple correlation of

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

appropriations ρ=-0.621. Institutions that lost the most in state appropriations, such as UC-Berkeley, tended to have the largest gains in tuition revenues.

Summarized in a regression context, the first panel of Table 6 shows estimates of the link between state appropriations and total tuition revenues for three categories of public research universities. In log form, this association is -0.249 for the group of AAU universities, but not distinguishable from zero for the broader research university or flagship groups.

Of course, total tuition revenue can change through the channels of price and quantity – that is, the tuition charges at each level of enrollment residency and the number of enrolled students at each tuition level. 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. [36] While all coefficients are negative, they vary in magnitude with the relative changes appreciably larger for in-state than for out-of-state tuition revenues. For the in-state tuitions (Panel B), a 10% relative decline in appropriations links to about a 2.5% increase in tuition at all research institutions, a 2.6% increase at flagship universities, and a 2.6% increase at the AAU institutions. The magnitude of the effect of appropriations on out-of-state tuition is more muted, with point estimates consistently indistinguishable from zero. Figure 6 illustrates the changes for in-state and out-of-state tuition revenues relative to changes in state appropriations. It is worth emphasizing that the university administrators are sharply limited by market forces in the extent to which they can raise out-of-state tuition as students paying this rate often have close

[36] 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.

substitutes in the form of other public universities or private universities; because in-state students are likely to have few close substitutes at comparable prices one might expect that political constraints on price increases are relaxes somewhat in the face of appropriation cuts.

Table 7 looks at how changes in foreign student enrollment are reflected in tuition revenue changes. Represented in log form with institution and year fixed effects, panel A shows a modest yet statistically significant link between foreign student enrollment and tuition revenues among the AAU institutions, as well as the flagship universities, but the relationship is smaller in magnitude for the broader group of research universities.

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 the panel B of Table 7. We find that foreign undergraduate students generate additional revenue fairly closely aligned with the average "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.

4.5 Supplemental Results (and Questions)

In our theoretical model, we assumed an unbounded 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, domestic out-of-state, and in-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, or the SAT, which distinguishes math and verbal performance. Table 8 shows how increasing foreign enrollment is reflected in ACT and SAT scores at the 25th percentile for incoming undergraduates enrolled at the three groups of public research universities. In brief, we find that increasing foreign enrollment leads to little change in the ACT scores, very modest gains in the SAT math scores, and small but significant reductions in the SAT verbal scores, a finding that likely reflects that many foreign students are not native English speakers. It is worth underscoring that these effects are quite small even when statistically significant.

4.6 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-tuition-paying undergraduates from abroad. But just how quantitatively important is this channel of adjustment to different universities? Looking at the period from 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 tuition charged to in-state students. This decomposition can be expressed as:

$$\Delta \frac{Tuition\ Revenue}{Students} = (\Delta s_o \times \overline{D_t}) + \left(\Delta s_f \times \overline{D_t}\right) + (\overline{s_o} \times \Delta D_t) + \left(\overline{s_f} \times \Delta D_t\right) + \Delta T_i$$

where D_t is the difference between in-state and out-of-state tuition, s_o is the domestic out-of-state share of total undergraduate enrollment, s_f is the foreign share of enrollment, $1- s_o- s_f$ is the in-

state share of 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 higher education price index (HEPI).

Table 9 shows this decomposition for AAU universities. The first 5 columns show each right-hand side term divided by the total change in tuition revenue per student to show the percent of the tuition revenue change accounted for by each component. The final two columns show the change in appropriations per undergraduate student and the change in tuition revenue 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.[37]

The measures shown reflect the relative importance of changes in tuition price levels for in-state and out-of-state students, along with changes in their representation in the student body. 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.

Turning to the role of the change in foreign student enrollment, shown in the first column of Table 9, we find that the increase in foreign students accounts for about 22% of the increase in tuition revenues, on average. Notably, for a modest number of universities, such as Illinois, Indiana, and Ohio State, the change in foreign student enrollment accounts for well over 40% of the change in tuition revenues over the interval.

[37] 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.

Section 5. Conclusion

The dramatic increase in foreign undergraduates at U.S. public research universities is closely coupled with institutional adjustments 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. The theoretical framework and evidence presented in this analysis suggests that expanding foreign enrollment at the undergraduate level is an important channel through which public universities buffer changes in state appropriations.

While we are not able to do a full welfare analysis, our results suggest that while added foreign students do not fully offset the adverse consequences of declines in state appropriations they nonetheless do offset some of the losses from declines in state appropriations. In turn, additional foreign undergraduate students are, on average, associated with some decline in in-state enrollment.

The capacity of public universities to use this margin of adjustment depends critically on a supply of well-qualified potential undergraduates from abroad with the capacity to pay the tuition charged by U.S. universities. While this supply has been plentiful in the last decade, owing primarily to 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. universities is not likely to remain constant in future decades. Growth in home-country institutions of close quality or negative shocks to home-country economies would likely drain this pool of students from abroad.

What also seems clear is that not all universities are in an equally good position to attract foreign students. In general, our results are consistent with the notion that more research-intensive universities have been better positioned to counter the impact of state budget cuts through increasing foreign undergraduate enrollment.

Beyond changes in the composition of undergraduate enrollment, changes in state appropriations are also associated with increase in in-state tuition levels. While added revenue from in-state tuition increases appears to count for the majority of additional tuition revenue generated between 2007 and 2012, research universities would have had to navigate reductions in resources per student or yet larger increases in in-state tuition in the absence of the large pool of foreign students.

The dramatic increase in the number foreign undergraduates on U.S. campuses over the past decade raises questions about the impact of this influx. Beyond impacts on the number of in-state students, the concentration of foreign students in certain majors such as business, engineering, and economics, it is possible that some universities may experience domestic student crowd-out or reductions in per-student instructional resources in these majors. Also, some evidence suggests that the rapid expansion in the number of foreign students has generated institution-level administrative challenges, while others have questioned how well foreign students are integrated in U.S. universities, even as their student bodies are more internationally diverse (Jordan, 2015; Redden, 2014; Gareis, 2012). Finally, the substantial increase in the number of foreign undergraduate students in the U.S. may impact the both domestic and home country economies. While beyond the scope of this paper, these issues are worthy of future investigation.

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Table 1: Summary Statistics, Sample Mean - Selected Years

	Type of Public 4-Year University			
	Research	AAU	Flagships	Non-Research
2007				
1st Undergraduate Enrollment				
# Foreign Students	72	154	87	25
# In-State Students	2,757	3,973	2,845	1,318
# Out-of-State Students	658	1,014	1,098	165
Revenues, 2013 Constant Dollar				
State Appropriations	$241,331,146	$397,742,472	$299,144,727	$57,981,323
Tuition Revenue	$188,362,238	$338,900,270	$245,488,043	$76,791,389
Tuition Level, 2013 Constant Dollar				
Out-of-State Tuition	$21,239	$26,329	$22,328	$14,740
In-State Tuition	$7,318	$8,555	$7,521	$5,560
SAT I Verbal - 25th percentile	502	538	515	445
SAT I Math - 25th percentile	522	570	537	451
2012				
1st Undergraduate Enrollment				
# Foreign Students	168	441	217	30
# In-State Students	2,754	3,900	2,882	1,353
# Out-of-State Students	798	1,158	1,289	163
Revenues, 2013 Constant Dollar				
State Appropriations	$189,866,578	$298,381,649	$235,150,788	$47,317,514
Tuition Revenue	$256,562,687	$467,993,348	$329,562,230	$101,000,567
Tuition Level, 2013 Constant Dollar				
Out-of-State Tuition	$24,375	$29,576	$25,968	$16,589
In-State Tuition	$8,875	$10,236	$9,014	$6,641
SAT I Verbal - 25th percentile	504	532	517	445
SAT I Math - 25th percentile	527	579	543	457

Note: Data are for 4-year public universities. Monetary variables deflated by the Higher Education Price Index (HEPI) and presented in 2013 dollars. AAU represents American Association of Universities. Research classified based on Carnegie 2010 definitions of high or very high research activity. Non Research includes both Doctoral granting and Masters universities. Enrollment, test scorers and tuition rates data from ASC. Tuition revenue and state appropriations data from IPEDS.

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

Panel A	**Dependent Variable:** Ln Foreign 1st Year Enrollment							
	Research		AAU		Flagship		Non-Research	
Explanatory Variable	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Log(State Appropriations)	-0.617	-1.171	-0.720	-1.704	-0.755	-1.709	0.088	0.557
	(0.180)***	(0.431)***	(0.286)**	(0.703)**	(0.322)**	(0.661)***	(0.156)	(0.380)
Log(Population 18)	0.128	0.329	-1.167	-0.828	-0.032	0.005	0.437	0.306
	(0.323)	(0.431)	(0.716)	(0.647)	(0.485)	(0.455)	(0.422)	(0.704)
R-squared	0.350	0.338	0.634	0.615	0.480	0.450	0.063	0.055

Panel B	**Dependent Variable**: Ln Out-of-State 1st Year Enrollment							
	Research		AAU		Flagship		Non-Research	
Explanatory Variable	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Log(State Appropriations)	0.045	-0.073	0.095	-0.437	-0.006	0.418	-0.018	-0.467
	(0.135)	(0.218)	(0.256)	(0.413)	(0.210)	(0.282)	(0.134)	(0.255)*
Log(Population 18)	-0.678	-0.635	-0.580	-0.397	-0.830	-0.846	-0.541	-0.416
	(0.233)***	(0.286)**	(0.521)	(0.514)	(0.367)**	(0.351)**	(0.319)*	(0.264)
R-squared	0.248	0.246	0.231	0.198	0.320	0.298	0.041	0.022

Table 2A (continued)

Panel C	**Dependent Variable:** Ln In-State 1st Year Enrollment							
	Research		AAU		Flagship		Non-Research	
Explanatory Variable	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Log(State Appropriations)	0.098	0.138	0.053	-0.074	0.019	0.030	0.116	0.054
	(0.052)*	(0.091)	(0.059)	(0.085)	(0.052)	(0.105)	(0.050)**	(0.092)
Log(Population 18)	0.626	0.612	0.509	0.552	0.198	0.198	1.051	1.068
	(0.096)***	(0.113)***	(0.103)***	(0.075)***	(0.140)	(0.138)	(0.151)***	(0.234)***
R-squared	0.397	0.396	0.376	0.361	0.295	0.295	0.336	0.334

Panel D - First Stage	**Dependent Variable:** Log(State Appropriations)			
Explanatory Variable	Research	AAU	Flagship	Non-Research
Log(Total State Appropriations)	0.663	0.613	0.578	0.771
	(0.082)***	(0.119)***	(0.073)***	(0.095)***
R-squared	0.654	0.679	0.655	0.642
Partial R-squared	0.270	0.284	0.280	0.285
F- Statistic	65.55	26.66	63.64	66.04
Observations	2,121	547	791	3,162
Number of Universities	136	34	50	285

Notes: Overall state appropriations to higher education are used as an instrument for institution-level state appropriations in the IV regressions. All regressions include institution and year fixed effects. Institution-year observations are weighted by the undergraduate population at baseline (1996). Robust standard errors reported in parentheses are clustered at the university level in the OLS and at the state level in the IV.

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

Panel A **Dependent Variable:** Foreign 1st Year Enrollment

	Research		AAU		Flagship		Non-Research	
Explanatory Variable	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Log(State Appropriations)	-171.121	-279.410	-342.709	-315.879	-269.172	-372.264	1.406	9.153
	(62.716)***	(79.569)***	(130.484)**	(196.129)	(104.245)**	(141.419)***	(6.113)	(11.718)
Log(Population 18)	-15.380	24.061	-460.115	-469.332	-41.298	-37.301	16.272	14.176
	(64.504)	(70.379)	(198.852)**	(187.211)**	(96.118)	(94.865)	(12.328)	(21.012)
R-squared	0.293	0.279	0.578	0.578	0.424	0.415	0.053	0.051

Panel B **Dependent Variable**: Out-of-State 1st Year Enrollment

	Research		AAU		Flagship		Non-Research	
Explanatory Variable	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Log(State Appropriations)	-66.672	-136.684	-265.559	-1,023.314	-197.583	-58.725	-5.187	254.335
	(88.530)	(205.552)	(129.635)**	(349.865)***	(193.244)	(323.671)	(27.308)	(189.894)
Log(Population 18)	-229.148	-203.647	-261.311	-0.972	-562.608	-567.992	-70.632	-331.481
	(264.653)	(374.636)	(562.871)	(507.336)	(365.336)	(356.809)	(56.127)	(363.008)
R-squared	0.253	0.252	0.303	0.209	0.353	0.350	0.054	0.219

Table 2B (continued)

Panel C	**Dependent Variable:** In-State 1st Year Enrollment							
	Research		AAU		Flagship		Non-Research	
Explanatory Variable	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Log(State Appropriations)	317.338	534.786	179.667	209.744	-53.347	26.622	147.109	155.631
	(164.096)*	(274.161)*	(227.010)	(516.124)	(140.502)	(297.631)	(87.370)*	(186.061)
Log(Population 18)	1,971.730	1,892.530	2,024.811	2,014.477	713.165	710.064	1,733.811	1,731.372
	(358.932)***	(399.536)***	(437.286)***	(283.533)***	(339.284)**	(334.624)**	(311.193)***	(558.338)***
R-squared	0.389	0.385	0.333	0.333	0.289	0.288	0.342	0.342

Panel D - First Stage	**Dependent Variable:** Log(State Appropriations)			
Explanatory Variable	Research	AAU	Flagship	Non-Research
Log(Total State Appropriations)	0.663	0.613	0.578	0.771
	(0.082)***	(0.119)***	(0.073)***	(0.095)***
R-squared	0.654	0.679	0.655	0.642
Partial R-squared	0.270	0.284	0.280	0.285
F- Statistic	65.55	26.66	63.64	66.04
Observations	2,121	547	791	3,162
Number of Universities	136	34	50	285

Notes: Overall state appropriations to higher education are used as an instrument for institution-level state appropriations in the IV regressions. All regressions include institution and year fixed effects. Institution-year observations are weighted by the undergraduate population at baseline (1996). Robust standard errors reported in parentheses are clustered at the university level in the OLS and at the state level in the IV.

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

	Dependent Variable: In-State 1st Year Enrollment			
Explanatory Variable	Research	AAU	Flagship	Non-Research
Out-of-State 1st Year Enrollment	0.153	0.017	0.086	0.060
	(0.122)	(0.147)	(0.095)	(0.278)
Foreign 1st Year Enrollment	-0.550	-0.557	-0.272	1.265
	(0.198)***	(0.259)**	(0.174)	(0.501)**
Log(Population 18)	2,084.228	1,775.804	760.656	1,426.968
	(397.636)***	(321.166)***	(322.178)**	(261.543)***
R-squared	0.403	0.360	0.297	0.322
Observations	2,184	550	796	3,194
Number of Universities	137	34	50	288

Notes: Overall state appropriations to higher education are used as an instrument for Ln Foreign 1st Year Enrollment in the IV regressions. All regressions include institution and year fixed effects. Institution-year observations are weighted by the undergraduate population at baseline (1996). Robust standard errors reported in parentheses are clustered at the university level in the OLS and at the state level in the IV.

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 Instructional Expenditures)			
Explanatory Variable	Research	AAU	Flagship	Non-Research
Log(State Appropriations)	0.150	0.007	0.148	0.273
	(0.086)*	(0.058)	(0.094)	(0.038)***
Log(Population 18)	0.168	0.014	-0.044	0.105
	(0.105)	(0.190)	(0.110)	(0.089)
R-squared	0.869	0.919	0.866	0.889

	Log(Instructional - salaries and wages)			
Explanatory Variable	Research	AAU	Flagship	Non-Research
Log(State Appropriations)	0.177	0.080	0.188	0.255
	(0.085)**	(0.045)*	(0.083)**	(0.033)***
Log(Population 18)	0.256	0.033	-0.037	0.303
	(0.113)**	(0.237)	(0.134)	(0.100)***
R-squared	0.771	0.941	0.857	0.849
Observations	1,717	443	651	3,510
Number of Universities	126	32	47	261

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

	Dependent Variable: Log(Expenditures for support services)			
Explanatory Variable	Research	AAU	Flagship	Non-Research
Log(State Appropriations)	0.376	0.247	0.325	0.403
	(0.098)***	(0.102)**	(0.112)***	(0.058)***
Log(Population 18)	-0.438	-0.832	-0.548	-0.193
	(0.181)**	(0.317)**	(0.229)**	(0.146)
R-squared	0.666	0.758	0.709	0.708
	Dependent Variable: Log(Expenditures for research)			
Explanatory Variable	Research	AAU	Flagship	Non-Research
Log(State Appropriations)	0.026	0.005	0.187	-0.045
	(0.169)	(0.120)	(0.179)	(0.183)
Log(Population 18)	0.085	0.118	-0.240	0.142
	(0.188)	(0.223)	(0.135)*	(0.551)
R-squared	0.602	0.909	0.732	0.216
Observations	1,717	443	651	3,510
Number of Universities	126	32	47	261

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 university non-instructional expenditure categories, 1996-2012

	Dependent Variable: Ln Tuition Revenue		
Explanatory Variable	Research	AAU	Flagship
Log(State Appropriations)	-0.082	-0.245	-0.152
	(0.063)	(0.075)***	(0.098)
Log(Population 18)	0.341	0.124	-0.037
	(0.118)***	(0.155)	(0.130)
R-squared	0.805	0.884	0.843
	Dependent Variable: Ln In-State Tuition		
Explanatory Variable	Research	AAU	Flagship
Log(State Appropriations)	-0.264	-0.322	-0.296
	(0.056)***	(0.117)***	(0.085)***
Log(Population 18)	0.739	0.831	0.563
	(0.112)***	(0.183)***	(0.173)***
R-squared	0.887	0.916	0.908
	Dependent Variable: Ln Out-of-State Tuition		
Explanatory Variable	Research	AAU	Flagships
Log(State Appropriations)	-0.058	-0.028	0.008
	(0.044)	(0.092)	(0.066)
Log(Population 18)	0.171	0.618	0.278
	(0.085)**	(0.217)***	(0.152)*
R-squared	0.900	0.903	0.890
Observations	2,186	528	797
Number of Universities	136	34	50

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

Panel A	**Dependent Variable:** Ln (Tuition Revenue)		
Explanatory Variable	Research	AAU	Flagship
Ln Foreign 1st Year Enrollment	0.018	0.070	0.045
	(0.010)*	(0.017)***	(0.016)***
Log(Population 18)	0.306	0.108	-0.049
	(0.122)**	(0.151)	(0.132)
R-squared	0.808	0.891	0.847
Observations	2,184	529	795
Number of Universities	136	34	50

Panel B	**Dependent Variable:** Tuition Revenue (Levels)		
Explanatory Variable	Research	AAU	Flagship
In-state Undergrads	1,751.705	6,114.817	5,026.125
	(1,210.891)	(3,045.659)*	(3,909.038)
Out-state Undergrads	13,494.231	17,675.366	17,729.168
	(2,466.089)***	(5,880.349)***	(5,324.983)***
Non-resident Undergraduates	38,145.503	41,979.309	45,187.919
	(11,409.255)***	(14,792.541)***	(21,070.485)**
US Graduate Students	16,988.400	15,056.759	8,714.826
	(3,701.755)***	(7,788.387)*	(9,095.163)
Foreign Graduate Students	36,185.562	8,106.566	33,882.986
	(9,833.030)***	(19,886.071)	(21,229.295)
R-squared	0.763	0.573	0.707
Observations	943	229	345

Notes: Panel B had lower number of observations because graduate student enrollment is only available after 2005 in the ACS. Panel A includes 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

	Dependent Variable: Log(ACT Composite - 25th percentile)		
Explanatory Variable	Research	AAU	Flagship
Ln Foreign 1st Year Enrollment	-0.001	0.003	0.004
	(0.003)	(0.006)	(0.005)
Log(Population 18)	-0.028	-0.109	-0.086
	(0.030)	(0.061)*	(0.040)**
R-squared	0.439	0.584	0.544
	Dependent Variable: Log(SAT I Math - 25th percentile)		
Explanatory Variable	Research	AAU	Flagship
Ln Foreign 1st Year Enrollment	0.006	0.005	0.012
	(0.003)**	(0.004)	(0.005)**
Log(Population 18)	-0.043	-0.170	-0.082
	(0.024)*	(0.040)***	(0.036)**
R-squared	0.399	0.659	0.549
	Dependent Variable: Log(SAT I Verbal - 25th percentile)		
Explanatory Variable	Research	AAU	Flagship
Ln Foreign 1st Year Enrollment	-0.008	-0.019	-0.011
	(0.003)**	(0.006)***	(0.006)*
Log(Population 18)	0.020	-0.028	-0.019
	(0.022)	(0.051)	(0.032)
R-squared	0.149	0.238	0.209
Observations	1,646	413	595
Number of Universities	122	29	46

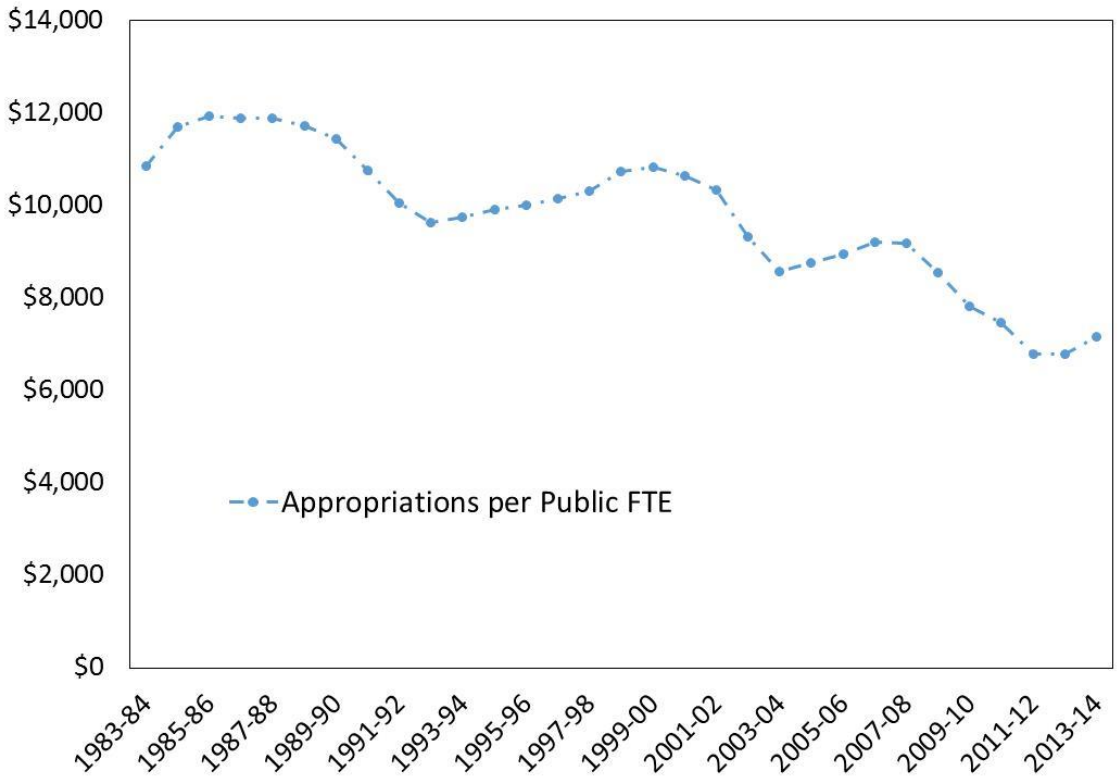
Notes: All regressions include institution and year fixed effects. Institution-year observations are weighted by the undergraduate population at baseline (1996). Robust standard errors clustered at the university level are reported in parentheses.

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

Institution Name	$\Delta s_f * Dt$	$\Delta s_0 * Dt$	$s_f * \Delta Dt$	$s_0 * \Delta Dt$	ΔT	$\Delta\left(\frac{App}{Ugrad}\right)$	$\Delta\left(\frac{Rev}{Ugrad}\right)$
University of Arizona	8.76%	-20.68%	1.83%	14.75%	95.33%	-7642	3783
UC-Berkeley	37.43%	0.73%	-0.38%	-0.79%	63.00%	-11864	4311
UC-Davis	22.53%	8.58%	-0.31%	-0.37%	69.57%	-8871	2246
UC-Irvine	25.72%	-7.87%	-0.36%	-0.29%	82.80%	-2691	2725
UC-Los Angeles	26.37%	18.49%	-0.29%	-0.29%	55.73%	-13315	5096
UC-San Diego	34.53%	4.72%	-0.28%	-0.25%	61.28%	-4757	3652
UC-Santa Barbara	17.13%	-0.69%	-0.22%	-1.57%	85.35%	-5965	2174
U Colorado Boulder	9.15%	32.90%	-0.08%	-1.57%	59.60%	-1030	3667
University of Florida	-0.27%	-9.94%	1.61%	7.38%	101.22%	-6718	2061
Georgia Tech	32.22%	-15.54%	-4.71%	-26.33%	114.37%	-8682	2550
U Illinois - UC	48.21%	-0.84%	-2.05%	-3.86%	58.54%	-1593	2544
Indiana University	57.20%	-63.93%	10.54%	59.06%	37.12%	-1878	1746
Iowa State University	29.99%	41.31%	0.49%	2.13%	26.08%	-4924	1708
University of Iowa	36.66%	11.36%	3.08%	33.70%	15.20%	-6955	2951
University of Kansas	13.74%	-8.25%	3.63%	22.88%	68.00%	-948	2273
University of Maryland	31.63%	-86.36%	15.66%	140.67%	-1.60%	-559	386
University of Michigan	15.91%	14.50%	5.22%	32.13%	32.25%	-3085	2364
Michigan State University	25.88%	1.43%	3.92%	7.24%	61.53%	-3666	4078
University of Minnesota	20.22%	-8.38%	1.71%	13.02%	73.42%	-5713	3541
University of Missouri	5.13%	27.50%	1.03%	8.70%	57.64%	-4695	3238
Rutgers University	23.20%	-18.38%	10.31%	37.82%	47.04%	-5898	620
University at Buffalo	26.65%	-1.07%	20.03%	6.30%	48.09%	-5790	2110
Stony Brook University	12.50%	11.69%	13.32%	10.37%	52.13%	-8327	1947
University North Carolina	6.99%	4.25%	1.24%	15.19%	72.33%	-5457	3254
Ohio State University	69.37%	5.30%	3.26%	7.56%	14.51%	-3173	1057
University of Oregon	13.92%	25.80%	4.51%	19.21%	36.56%	-2694	6925
Pennsylvania State	26.15%	19.87%	-0.09%	-0.71%	54.77%	-4110	2733
University of Pittsburgh	9.36%	30.54%	-0.39%	-5.13%	65.62%	-4576	2847
Texas A & M University	-1.04%	38.62%	-2.10%	-5.37%	69.88%	-2139	-329
University Texas-Austin	10.66%	-0.53%	11.08%	14.09%	64.70%	-1922	1095
University of Virginia	8.04%	-8.31%	5.97%	36.16%	58.14%	-3871	3575
University of Washington	24.34%	-3.16%	0.84%	2.25%	75.74%	-6934	5890
University of Wisconsin	19.52%	6.27%	0.34%	2.67%	71.20%	-2076	2573
Purdue University	51.74%	3.88%	3.32%	10.80%	30.26%	-364	3340
All AAUs	**24.04%**	**3.85%**	**1.95%**	**8.15%**	**62.01%**	**-4620**	**2711**

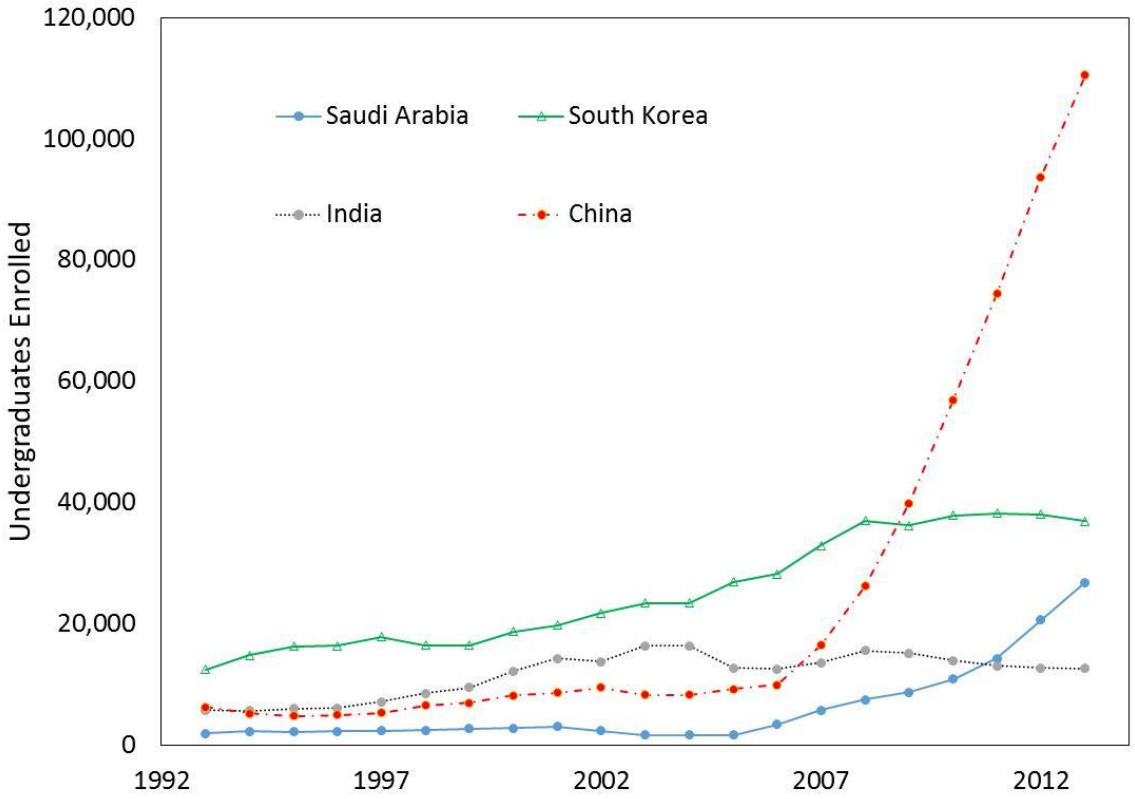
All changes are 2007 to 2012. s_f is share of undergraduate population that is nonresident alien. s_0 is share of undergraduate population that is out of state domestic students. ΔT is the change in in-state tuition rates. Dt is the tuition differential between out-of-state and in-state tuitions. $\Delta\left(\frac{App}{Ugrad}\right)$ 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.

Figure 1. Appropriations per Full-Time Equivalent Student Over Time, 1983-2013



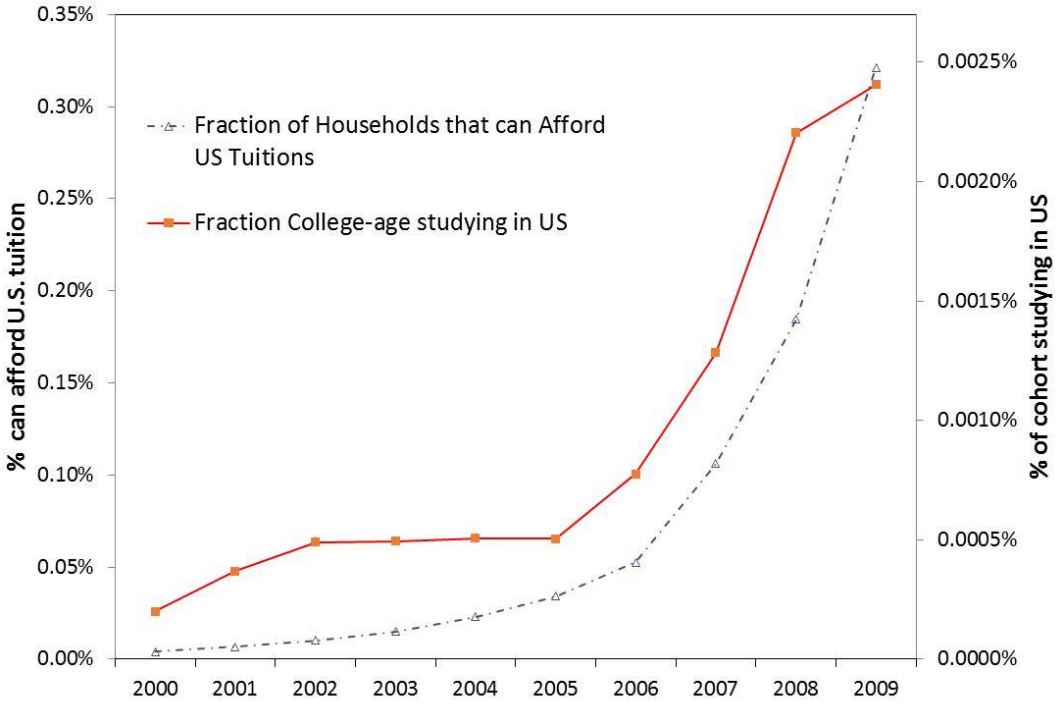
Source: *Trends in College Pricing* and *Digest of Education Statistics*, various years. All figures are deflated by the Higher Education Price Index (HEPI).

Figure 2: Country trends in foreign undergraduate enrollment at U.S. higher education institutions, 1992-2013



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

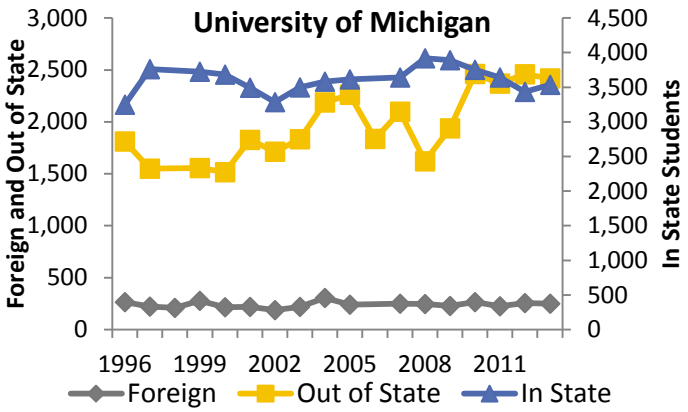
Figure 3. Fraction of Chinese college-age population studying abroad and financial capacity, 2000-2009

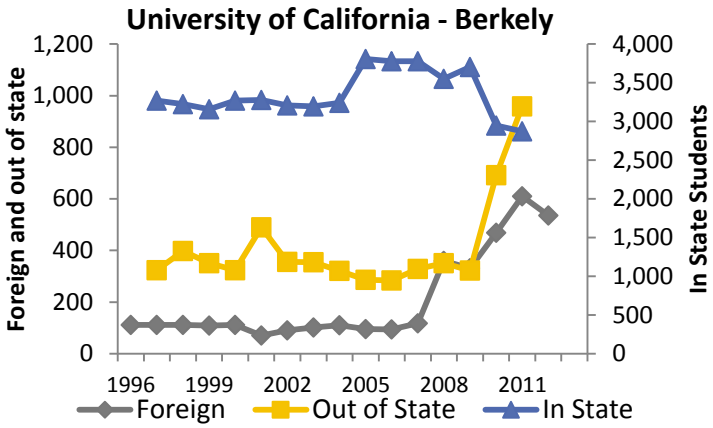


Source: Authors' calculations, based on income distribution data from the World Bank and Average Tuition, Room and Board for Out-of-State Student at a public university from IPEDS. See footnote 19 for additional details.

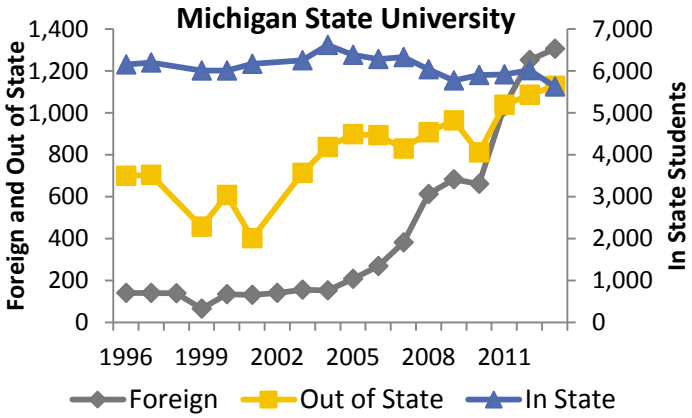
Figure 4. Trends in Enrollment by Institution – California and Michigan

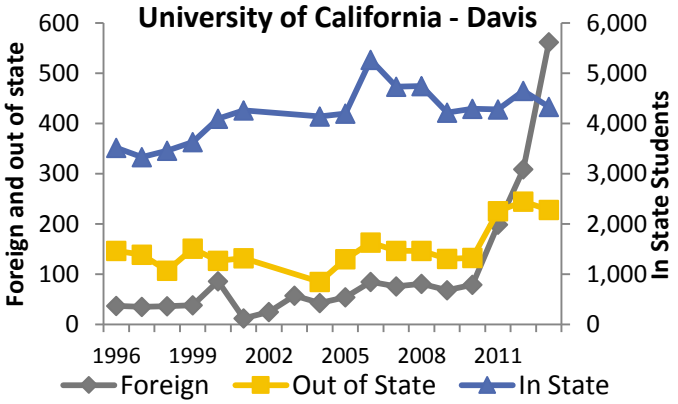
Panel A



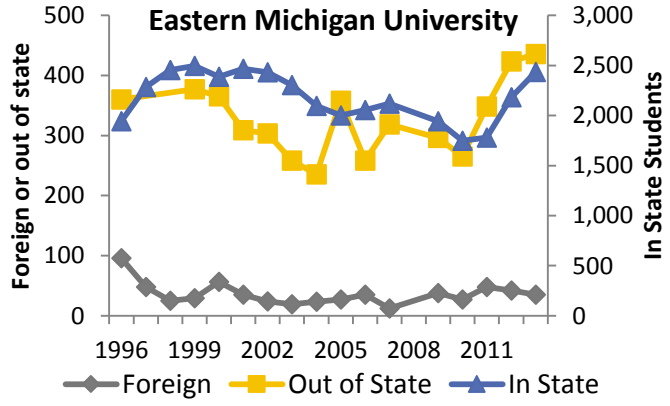


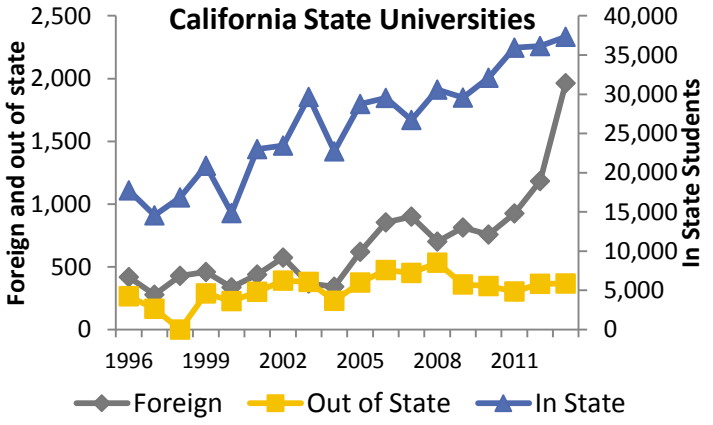
Panel B





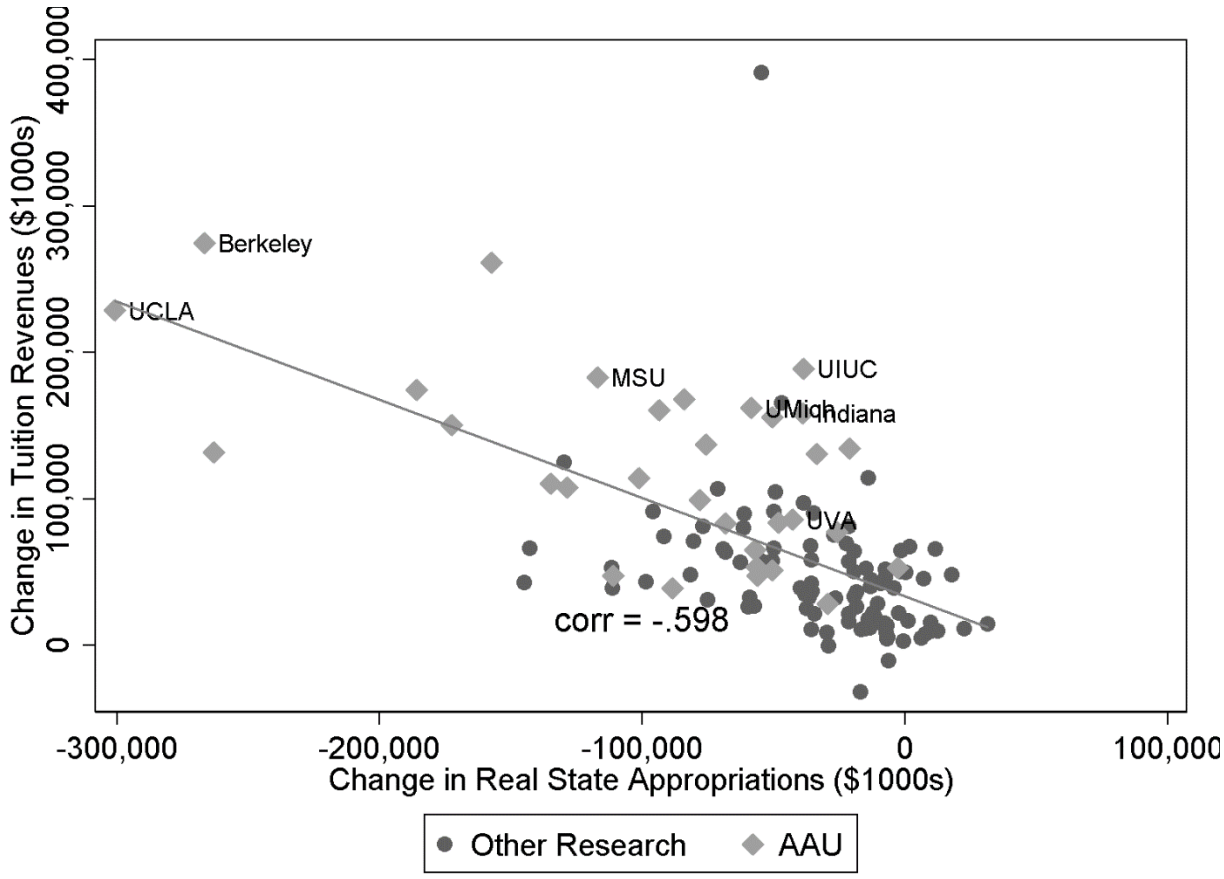
Panel C





Note: Enrollment numbers from ASC data 1996 to 2012. Figures show number of full time first year students by residency and visa status. The left panels show the numbers for California public universities, whereas the right panel shows the numbers for public universities in Michigan. 'California State Universities' is an aggregate over 23 different campuses.

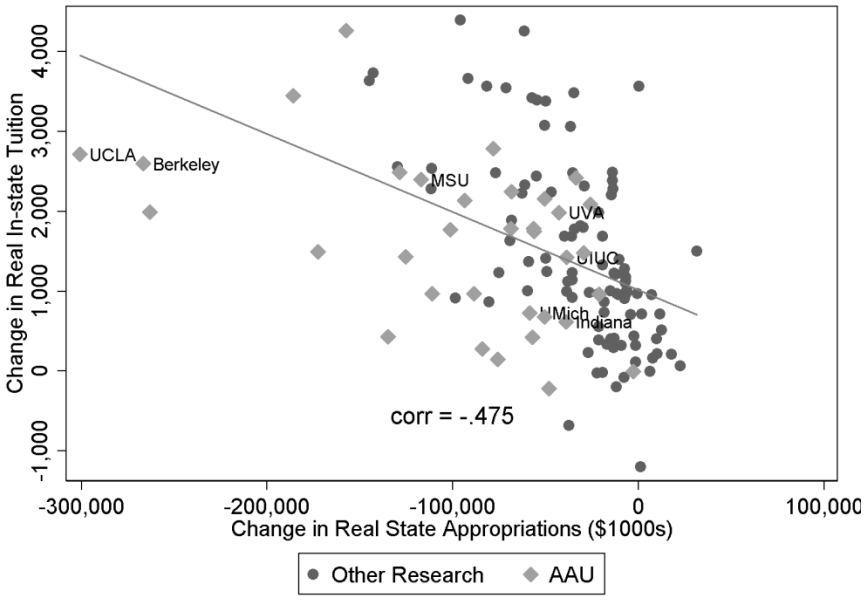
Figure 5. Change in Appropriations and Tuition, 2007 to 2012



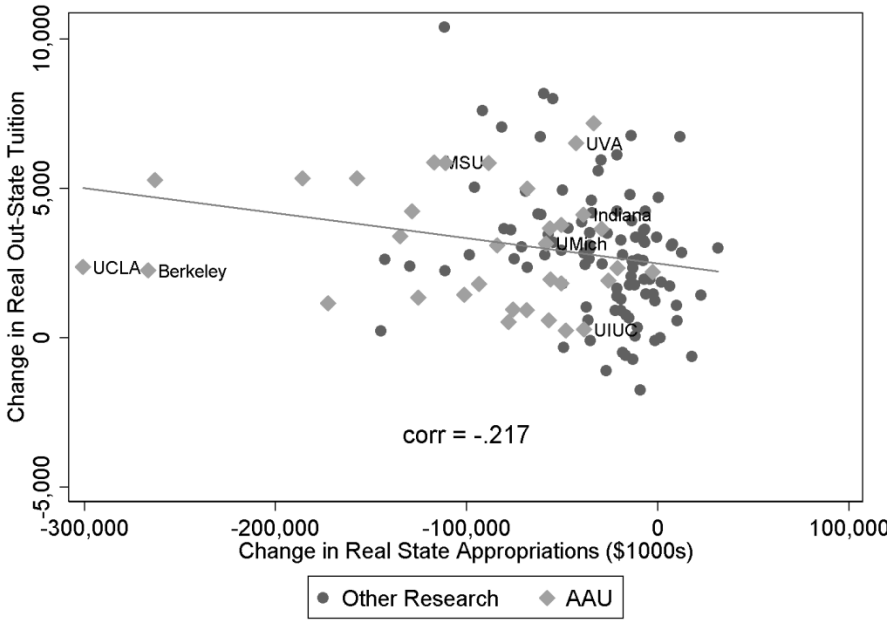
Note: Changes are defined as the difference between the 2012 value and the 2007 value. All monetary units are deflated by Higher Education Price Index (HEPI) 2012. State appropriations and tuition revenue data from IPEDS.

Figure 6. Change in Appropriations and Tuition Levels, 2007 to 2012

A. In-State



B. Out-of-State



Note: Changes are defined as the difference between the 2012 value and the 2007 value. All monetary units are deflated by Higher Education Price Index (HEPI) 2012. State appropriations data from IPEDS, tuition levels from ASC.

Appendix (For online publication)

Appendix 1: Data Preparation

The data-set assembled for this project is at the university-year level for research public universities. The 2010 Carnegie Classification groups these public universities intro three categories: (1) Very high research activity, (2) High research activity, and (3) Doctoral universities. In all, there are 177 public four-year universities across eighteen years (1997 to 2014) of which 138 universities are in the first 2 categories. As an additional category we also include 265 Master's colleges as a comparison.

Institution data for state appropriations comes from IPEDS, where it is reported consistently till 2012. While IPEDS reports both state and federal appropriations, we use the former since that is what drives the variation that we are interested in analyzing. The IPEDS also has valuable information on tuitions, tuition revenues, and SAT/ACT percentiles. We use the Delta-cost dataset to get information on expenditures. Since the Delta-cost ends in 2010, we update it with the latest IPEDS rounds, keeping in mind that financial reporting standards changed in 2010. IPEDS also has data on aid, and on the number of students in the fall-cohort that are from in-state and out-of-state. . We complement the state appropriations data using the Universities Financial Statements (Annual Financial Reports), when this information was missing on IPEDS. State level data on total appropriations comes from the State Higher Education Finance report (SHEF) provided by the State Higher Education Executive Officers' (SHEEO) in the website <http://www.sheeo.org/projects/shef-%E2%80%94-state-higher-education-finance>.

For enrollment, we use the Annual Survey of Colleges (ASC), which reports enrollment consistently from 1997 through to 2013. The ASC reports the number of foreign freshmen and undergraduates, and the fraction that are from out-of-state. Given the fraction of out-of-state, the number of foreign students, and the total enrollment, we back out the in-state enrollment for freshmen and for all undergraduates. The ASC also has data on tuitions (in-state and out-of-state), international financial aid, and SAT/ACT percentiles for the freshmen.

We combine these data sets with data on freshmen enrollment from each state/country using the Residence and Migration Surveys. We also use the Web CASPAR data on foreign graduate enrollment.

Foreign students in the Residence and Migration surveys depend on where the students reside before attending college. Whereas the ASC and the Common Data Sets (CDS) define foreign

students as Non Resident Aliens in the following manner: "*A person who is 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*." Since we use the ASC data for our enrollment variables, foreign students are being counted based on their visa status rather than their state of residence.

In order to control for changes to the local economy, we compile historical Census estimates of the population at age 18 by state, and Bureau of Labor Statistics (BLS) data on the state unemployment rate for every year in our data.

Missing data on enrollment, tuitions and other variables are hand-coded from the universities Common Data Sets (CDS) available on their Institutional Research webpages and the University of California System available at <http://universityofcalifornia.edu/uc-system>. Missing data on appropriations, revenues (tuition and others), expenditures are hand-coded from university financial statements, when available. By using the complement data on enrollment and state appropriations, we add 139 observations to the Research University sample, 84 to the Flagship, 49 to the AAU and 4 to the Non-Research.[38]Our main results are robust to excluding the hand-coded data.

The CDS reports the fraction of out-of-state students (excluding foreign students from both the numerator and denominator). We use the total enrollment and the number of foreign students to then back out the number of out-of-state students. We weight our regressions based on the size of the undergraduate cohort in the year preceding the first year of the data. We replace gross outliers with missing values.

All the monetary variables (including state appropriations, tuitions and expenditures) are deflated by the Higher Education Price Index (HEPI). Since most of our regression formulations include the logged monetary variable and fixed effects, the method of deflation for these regressions is inconsequential, and the deflation only affects the figures and levels regressions.

Robustness Checks

[38] We also exclude observations of University of Buffalo before 2002. We identify a significant data break in the enrollment series of this university, probably caused by a campus merges. The main results of this paper are robust to this exclusion.

In this paper, we identify a negative relationship between state appropriations and foreign enrollment in public universities. In table A1, we present robustness checks for this result. In Panel A, we control our OLS and IV regressions for state level unemployment. One could claim that state economic conditions are correlated with state appropriations and might affect enrollment decisions of students. Nonetheless, we do not find any significant effect of state unemployment on total enrollment in public universities. In addition, state appropriations coefficients are quantitatively similar to those estimated in Table 2. This result suggests that most universities receive applicants whose enrollment choices are not sensitive to labor market shocks in our four samples.

In Panel B, we include universities' specific time trends to our estimation equation. This flexible specification allows universities to follow different linear time trends in a limited but potentially revealing way. We only show OLS specifications, as we cannot obtain a full rank variance-covariance matrix in the IV specification. We find smaller but still significant coefficients of state appropriations on the Research, AAU and Flagship samples. Similar to Table 2, we do not find evidence of a relationship between state appropriations and foreign enrollment in Non-Research Universities.

Finally, throughout the paper, institution-year observations are weighted by the undergraduate population at baseline (1996). By doing so, we aim to prevent our findings from being influenced by smaller colleges that substantially increased foreign enrollment during the period of analysis. Nonetheless, we show in Panel C that our results are robust to this weighting procedure. We indeed find significant effects of state appropriations on unweighted OLS and IV specifications for Research, Flagship and AAU universities. Overall, while we could identify some non-trivial changes in magnitudes across these different specifications we conclude that our main results are robust to state economic conditions, university time trends and weighing procedures.

Appendix Table A1: Foreign Enrollment and Appropriations: Robustness to controls (State Unemployment Rate and University Specific Time Trends), 1996-2012

Panel A	**Dependent Variable:** Ln Foreign 1st Year Enrollment							
	Research		AAU		Flagship		Non-Research	
Explanatory Variable	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Log(State Appropriations)	-0.647	-1.467	-0.661	-1.796	-0.738	-1.969	0.059	0.636
	(0.176)***	(0.497)***	(0.288)**	(0.690)***	(0.326)**	(0.758)***	(0.161)	(0.504)
Log(Population 18)	0.149	0.479	-1.127	-0.844	-0.048	0.138	0.472	0.252
	(0.329)	(0.404)	(0.714)	(0.655)	(0.467)	(0.461)	(0.422)	(0.720)
State Unemployment Rate	-0.013	-0.052	0.024	-0.019	0.007	-0.053	-0.015	0.018
	(0.032)	(0.038)	(0.063)	(0.043)	(0.045)	(0.054)	(0.025)	(0.039)
R-squared	0.350	0.327	0.635	0.611	0.481	0.436	0.064	0.052
F -Statistic		65.55		26.66		63.64		66.04

Panel B	**Dependent Variable:** Ln Foreign 1st Year Enrollment			
	Research	AAU	Flagship	Non-Research
Explanatory Variable	OLS	OLS	OLS	OLS
Log(State Appropriations)	-0.452	-0.513	-0.635	-0.297
	(0.135)***	(0.219)**	(0.192)***	(0.137)**
Log(Population 18)	-1.109	-1.578	-1.257	-1.703
	(0.250)***	(0.490)***	(0.280)***	(0.349)***
University Specific Trends	Yes	Yes	Yes	Yes
R-squared	0.527	0.689	0.618	0.306

Appendix Table A1 -Continuation

Panel C	**Dependent Variable:** Ln Foreign 1st Year Enrollment							
	Research		AAU		Flagship		Non-Research	
Explanatory Variable	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Log(State Appropriations)	-0.464	-0.616	-0.515	-1.219	-0.610	-1.091	0.052	0.570
	(0.182)**	(0.363)*	(0.282)*	(0.520)**	(0.338)*	(0.541)**	(0.139)	(0.452)
Log(Population 18)	0.267	0.314	-0.905	-0.675	0.080	0.087	-0.115	-0.267
	(0.306)	(0.420)	(0.720)	(0.705)	(0.446)	(0.421)	(0.403)	(0.600)
Unweighted	Yes		Yes		Yes		Yes	
R-squared	0.296	0.295	0.633	0.621	0.395	0.384	0.054	0.045
F -Statistic		87.13		24.67		71.56		72.50
Observations	2,125		550		794		3,170	
Number of Universities	136		34		50		281	

Notes: Overall state appropriations to higher education are used as an instrument for institution-level state appropriations in the IV regressions. Panel A controls for state-level unemployment rates. Panel B controls for university specific time trends. All Regressions include institution fixed effects. Regressions in Panels A and C include year fixed effects. Observations in Panels A and B weighted by the undergraduate population at baseline (1996). Robust standard errors reported in parentheses are clustered at the university level in the OLS and at the state level in the IV.

Appendix 2: An Extension of the Model with Endogenous In-State Tuition

In the model presented in the body of this paper, universities take both the in-state and out-of-state tuition as given. Over the period of our study, however, there was an increase in in-state tuitions that helped universities recover lost revenues from appropriations. Indeed, Table 6 displays a negative relationship between appropriations and in-state tuitions and our accounting exercise in Table 9 highlights how a significant fraction of lost appropriations was recovered by increases in in-state tuitions.

The assumption that out-of-state tuition levels are exogenous to the choices made by university administrators follows from the observation that competitive forces in the higher education market which includes private and public actors across states. However, one might think that because public universities hold some market power within states and, thus, an appropriate theoretical framework would allow for the endogenous determination of in-state tuition.

In this appendix, we extend the model to allow universities to set the in-state tuition subject to additional constraints. In our modified model, universities have monopsony power and choose the optimal level of the in-state tuition.

University's Problem

Increases in in-state tuition levels are associated with higher tuition revenue but lower the quality of in-state students; if the tuition is high, the best in-state students might seek alternatives either in private colleges and universities or other good state universities, thus decreasing the overall quality of the university. The existence of merit scholarships to attract high achieving in-state students is evidence that some in-state students are price sensitive in their college choice.

To incorporate this tradeoff, we modify the university's optimization problem by including an additional choice variable – the in-state tuition p_s :

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

Subject to the budget constraint:

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

There is, however, an additional constraint as mentioned above: a marginal increase in in-state tuition p_s will lower the quality of students by ε_s.

While the FOCs with respect to in-state, out-of-state and foreign enrollment, and investment are the same as before, there is an additional FOC associated with in-state tuitions:

$$K_s = -\frac{q_\theta \varepsilon_s}{\lambda}$$

This FOC highlights the tradeoff in increasing in-state tuitions. On the one hand, the marginal benefit from a dollar increase in in-state tuition is the revenue generated from in-state enrollment K_s. Large in-state student populations with the capacity to pay make increase opportunities for universities to increase tuition levels. On the other hand, there is a cost associated with raising revenues – the university loses potentially high quality students that are no longer willing to pay such high tuitions. These students may seek out private schools or better ranked state schools instead, thus lowering the average quality of the student body.

State Legislature's Problem

There is no change to the state legislator's optimization exercise except for an additional incentive compatibility constraint that comes out of the university's FOC with respect to in-state tuitions. The legislature's problem therefore boils down to:

$$max_{R(),g} K_s^{\beta} g^{1-\beta}$$

subject to the budget constraint:

$$Y = R + p_g g.$$

the incentive compatibility constraint of university:

$$R'(K_s) + p_s = \varphi_s - \frac{q_\theta \theta_s}{\lambda}$$

$$K_s = -\frac{q_\theta \varepsilon_s}{\lambda}$$

and the university's budget constraint:

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

Parametric Assumptions and Comparative Statics

In order to derive comparative statics for the model with endogenous in-state tuition, we build on the parametric model we have already set-up in the paper and highlight that the model can predict the observed empirical results from Table 6 under some additional assumptions.

Based on the appropriations contract and university technology presented in the section 2.4, we can describe optimal in-state enrollment and tuition decisions of the university from its FOC:

$$K_s^* = -\frac{\varepsilon_s}{\lambda^*}$$

$$\gamma + p_s^* = c + \frac{\mu_s K_s^*}{\lambda^*}$$

where the value of the Lagrangian multiplier λ^* is a function of θ_f, p_o and c derived in section 2.4. As a reminder, γ determines the relationship between state appropriations and in-state enrollment in the following manner: $R(K_s) = \gamma K_s$

Taking the total derivative with respect to the appropriations contract γ, we estimate how equilibrium in-state enrollment and tuition vary with more generous appropriations:

$$\frac{\partial K_s^*}{\partial \gamma} = -\frac{1}{\lambda^*}\frac{\partial \varepsilon_s}{\partial p_s}\frac{\partial p_s^*}{\partial \gamma}$$

$$1 + \frac{\partial p_s^*}{\partial \gamma} = \frac{\mu_s}{\lambda^*}\frac{\partial K_s^*}{\partial \gamma}$$

where $\frac{\partial \varepsilon_s}{\partial p_s}$ is the second derivative of the quality of student body with respect to in-state tuition. It describes how fast the quality of the student body declines with increases in in-state tuition. Rearranging the two equations above, we can derive the relationship between in-state tuition and the appropriations contract:

$$\frac{\partial p_s^*}{\partial \gamma} = \frac{-1}{1 + \frac{\mu_s}{{\lambda^*}^2}\frac{\partial \varepsilon_s}{\partial p_s}}$$

From this expression, one can see that $\frac{\partial \varepsilon_s}{\partial p_s} > 0$ is a sufficient condition for the model with endogenous tuition to predict that in-state tuition varies negatively with the appropriation contract, and in-state enrollment varies positively with the appropriations contract. As along as the quality of in state student body is sufficiently sensitive to tuition, the model predicts the negative relationship between appropriations and in-state tuitions found in Table 6.

We provide a parametric version for ε_s in order to derive a closed form solution for the university's and state legislature's problem. We assume that the decline in quality of the student body is a linear function of p_s:

$$\varepsilon_s = \pi(p_s - c) < 0$$

Where $\pi > 0$ and $c > p_s$ for any p_s. From the FOC with respect to tuition, we have that tuition is a direct function of enrollment of and in-state tuition.

$$p_s^* = c - \frac{\lambda^* K_s}{\pi}$$

This is the in-state student quality inverse demand curve. The amount of the "subsidy" depends on π and λ^*. From the FOC with respect to in-state enrollment, we have that:

$$K_s^* = \left(\frac{\lambda^* \pi}{\pi \mu_s + \lambda^{*2}}\right)\gamma \equiv \Delta\gamma$$

Given these, the state's problem is reduced to choosing the optimal amount of public goods g and γ:

$$max_{\gamma,g} \Delta^{\beta} \gamma^{\beta} g^{1-\beta}$$
$$such\ that: \quad Y = \Delta\gamma^2 + p_g g$$

The FOCs from the legislature's problem allows us to solve for the optimal level of in-state enrollment and appropriations as a function of exogenous state revenues Y:

$$\gamma^* = \left(\frac{\beta Y}{(2-\beta)\Delta}\right)^{\frac{1}{2}}, \; K_s^* = \left(\frac{\Delta\beta Y}{(2-\beta)}\right)^{\frac{1}{2}} \quad and \quad R^* = \left(\frac{\beta Y}{2-\beta}\right)$$

These results imply, as in the main body of the paper, that appropriations and in-state enrollment are an increasing function of exogenous state revenues, thus motivating our instrumental variables strategy.

Further, from the optimal in-state tuition equation, we show that tuitions are a decreasing function of state appropriations:

$$p_s^* = c - \frac{\lambda}{\pi}\left(\frac{\Delta\beta Y}{(2-\beta)}\right)^{\frac{1}{2}} = c - \frac{\lambda}{\pi}(\Delta R)^{\frac{1}{2}}$$

This result, therefore, is consistent with the empirical patterns in Table 6 which shows that a fall in appropriations is strongly associated with a rise in in-state tuitions.

From the university's FOCs, we get that the optimal number of out-of-state students K_o^* and investments I^* are the same as before. Foreign enrollment takes the following form:

$$K_f^* = \frac{p_o - c}{2\rho}\left(\frac{\alpha}{\theta_f}\right)^2 + \frac{\theta_f}{\mu_0} - \frac{\Delta\mu_s}{-\theta_f} R(Y)$$

This implies that a fall in state appropriations is associated with a rise in foreign enrollment (recall that $\theta_f < 0$). Furthermore, an increase in foreign student quality (represented by a fall in the absolute value of θ_f) is associated with high foreign enrollment.

Last, how a change in foreign student quality affects in-state enrollment depends on the size of the parameters in question. If $\lambda^2 < \pi\mu_s$ then an increase in the supply of well-qualified foreign students is associated with less in-state enrollment. This extension to the model, therefore, provides for the endogenous determination of in-state tuition levels and captures the facts that are salient in our regression results.

The choice to present the more parsimonious version of the model in the text reflects our focus on the basic link between changes in state appropriations and the enrollment of students from different points of origin.