

A PASSAGE TO AMERICA:
UNIVERSITY FUNDING AND INTERNATIONAL STUDENTS

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ABSTRACT

The pool of students in the global economy prepared for higher education and able to pay tuition at U.S. colleges and universities has expanded markedly in the last two decades, with a particularly notable increase among potential undergraduate students from China. Given the concentration of high quality colleges and universities in the U.S., there has been a substantial increase in the demand for enrollment among students from abroad. At the same time, substantial declines in state support, driven by contractions in state budgets, have occurred at public sector universities. For such universities, declines in state appropriations force a choice between increasing tuition levels, cutting expenditures, or enrolling a greater proportion of students paying full out-of-state tuition. In this paper, we present evidence showing that a significant set of public universities were able to take advantage of the expanding pool of potential students from abroad to provide a stream of tuition revenue that partially offsets declining state appropriations. Our analysis focuses on the interaction between the type of university experience demanded by students from abroad and the supply-side of the U.S. market. 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 most resource-intensive public universities. Our results tell a compelling story about the link between changes in state funding and foreign enrollment in recent years. In the absence of the pool of foreign students, many universities would have faced larger cuts to expenditures and potentially greater increases in in-state tuition charges.

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Substantial declines in state support for public higher education over the last few decades have produced marked adjustments in the U.S. higher education market. How public universities adjusted along various margins, particularly the fraction of students paying out-of-state tuition, is of substantial interest to economists and policy makers (Napolitano, 2016) alike. Income growth in emerging economies has enabled many students from abroad to pay for a U.S. education and, in turn, allowed university administrators facing funding declines to recover some revenues from full-fee paying students from abroad.

The United States' system of higher education is large, attractive to foreigners, and institutionally diverse: 4,627 degree-granting institutions enrolled more than 20.6 million students in 2014-15. On a per capita basis, the U.S. leads the world in the supply of collegiate opportunities, and boasts 31 of the 50 most highly ranked universities, by measures of research productivity (2016 Shanghai Rankings). Institutional diversity and stratification characterize the market for higher education: participants include private non-profits, for-profits, and public colleges and universities, while instructional resources per student vary dramatically (Winston, 1999 and Bound, Lovenheim, and Turner, 2010). The scale of the public sector is notable: public colleges and universities account for 63% of all BA degrees and 64% of all four-year university enrollment (2017 IPEDS).

Organized and governed at the state level, public universities typically receive substantial state subsidies and have a mandate to provide collegiate opportunities to in-state students, which is usually fulfilled via below-cost tuition rates and preferential treatment in admissions. State appropriations, however, have not only decreased as a share of the total costs of higher education in recent decades, but have also 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 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 ability of a particular public university to attract students from different residential locations – in-state, other U.S. states, and international – with sufficient academic and financial wherewithal determines the extent to which it can adjust along

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

enrollment margins. Public research universities with limited market power over domestic out-of-state students may need to look abroad.

The number of international undergraduate students in the United States has increased markedly since the beginning of the 21st century, rising by 67% from 288 thousand students in 2000 to 482 thousand in 2013 (2017 IPEDS). Despite previous downturns in public higher education budgets, the dramatic increase in enrollment from abroad is a recent phenomenon, encouraged by changing conditions abroad that have allowed universities to readily adjust their enrollment mix. Increased academic preparation at the secondary level, growth in incomes allowing families to pay U.S. tuitions, and persistently high returns to collegiate attainment have now made international enrollment a plausible adjustment margin for U.S. universities.

Such changes are particularly prominent in developing economies like China where secondary enrollment increased from 64 to 95 million between 1996 and 2012, while GDP per capita (in constant 2010 US\$) increased fourfold from about \$1,335 to \$5,336 over this interval (2017 World Bank Development Indicators). As home country universities struggle to meet this burgeoning demand for higher education, Chinese families have turned towards the U.S. While the recent increase in demand among students from China could potentially affect enrollment in all research universities, we show that public research universities suffering significant state appropriation cuts disproportionately turn to foreign students as a source of tuition revenue.

The broad hypothesis presented in this paper is that cuts in state appropriations, in an environment of increasing demand from abroad, have driven the dramatic growth in full-fare paying students from abroad at public research universities. We begin by demonstrating that improvements in secondary educational attainment in China and the increasing ability of Chinese families to pay for a U.S. education generated demand from abroad, allowing universities to admit a greater number of qualified full-fare paying students when required. We then assess the link between substantial declines in state funding faced by public universities and undergraduate enrollment.

State higher education budgets are often determined by what is left over after other spending priorities are accounted for, and changes in budgets depend on the interplay between revenue cycles and spending obligations, like Medicaid (Kane, Orszag and Apostolov, 2005). A particular university's funding, however, can be the outcome of a complex bargaining process between legislatures and universities, and this may undermine correlations between funding

shocks and foreign enrollment. Because state-level fluctuations in revenue and spending obligations are plausibly exogenous to post-secondary enrollment decisions at a particular university, we employ an instrumental variables strategy using variation at the state rather than the university 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. This relationship is robust to controlling for the state unemployment rate and other state economic measures. In simple calculations, our estimates imply that changes in appropriations can explain 30% of the foreign enrollment increase at public research universities and 50% of the increase at resource-intensive research universities.

In falsification tests, we find no indication of a greater increase in foreign enrollment at private universities in states experiencing declines in appropriations, suggesting that international students did not seek out states with falling budgets. Our results are also robust to two alternative instrument specifications: state disposable revenues, and state higher education budgets interacted with a university's baseline dependence on appropriations.

Having found evidence for a common effect, we examine the extent to which effects differ across universities. If non-research public universities have limited access to international students, there should be little foreign enrollment response at these institutions. Indeed, our empirical analysis shows that effects of decreases in state appropriations on foreign enrollment do not appear at public institutions outside the research sector, as they are arguably less attractive than alternatives at home. Additionally, the relationship is not significant for public universities that had steady access to domestic full-fee paying students.

In turn, increases in the enrollment of foreign students generate substantial gains in university tuition revenues, which partially offset the loss in appropriations and mitigate the need to raise in-state tuition rates or cut expenditures. The association between declines in appropriations and increases in foreign enrollment is 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 substantially larger than the pool of comparably prepared domestic out-of-state students.

Following this framework, in the first section we review trends in international participation in U.S. higher education at the undergraduate level and present evidence on the role of students from China in the recent expansion. In the second section, we outline the

institutional features of the U.S. market for higher education and present a conceptual model of public university behavior that considers university resource choice and selection of students. Section three outlines the empirical strategy and sources of data. Section four presents the results and the final section concludes.

Section 1. The Demand from Abroad and the Role of China

There is a long history of foreign participation in U.S. higher education at both the undergraduate and graduate levels, though the cross-country patterns of flows have changed markedly over time.² In 1993, Japan (with 31,960 students enrolled in the U.S.), Canada (13,149) and South Korea (12,521) were the three largest source countries for enrollment among foreign students at U.S. colleges and universities; but, by 2013, the landscape changed appreciably with Canada falling to fifth, Saudi Arabia³ jumping to second (26,865), and China leapfrogging ahead of the others (110,550). Figure 1 illustrates the dramatic increase in students from China, with a sharp shift that begins around 2006.

From 1998-2005, the yuan/dollar exchange rate remained effectively constant at 8.28 yuan/USD, but in mid-2005, the Chinese modified their currency valuation policies, allowing the yuan to appreciate. By January 2014, the yuan had appreciated by about 37% to trade at 6.05 yuan/USD. In addition, in June of 2005, Chinese and U.S. authorities extended the terms of student visas to allow for multiple entry 12-month visas, which reduced the administrative hurdles for Chinese students studying in the U.S.⁴ Between 2006 and 2013, enrollment of foreign undergraduate students rose 58%, from 234 to 370 thousand students. In academic year 2013-14, China, India, Saudi Arabia and South Korea accounted for more than 50% of foreign undergraduate enrollment, with China alone accounting for 30%. In fact, the growth in undergraduate students from China – from roughly 8 thousand students in 2003-04 to more than

² Unlike work visas such as the H-1B, student visas have not been subject to numerical constraints. The process for obtaining a student F visa requires prospective students to receive and accept an offer of admission from a U.S. college or university. More broadly, student visas include the F, M and J visas, which are all “non-immigrant visas” permitting temporary residency. The most common designation is the F-1 visa, which is issued to students admitted to an approved institution of learning. M visas are intended for study in vocational rather than academic programs, while J visas are intended for visitors and require a two-year home residency after the completion of the exchange program before return to the U.S.

³ The introduction of an explicit government fellowship for study abroad is clearly a contributing factor to the observed increase in enrollments among students from Saudi Arabia (Kurtz, 2012).

⁴ For more details on the visa policy change, see: <https://2001-2009.state.gov/r/pa/prs/ps/2005/47974.htm>

110 thousand in 2013-14 – accounts for 90% of the total increase in foreign undergraduates over this decade (*Open Doors*, Institute for International Education).

The enrollment demand among students from abroad for U.S. higher education institutions is a function of home country education markets and labor markets (Rosenzweig, 2006). Plausibly, four broad factors affect the demand from abroad to U.S. public universities: the number of students who can afford the cost of pursuing a college degree abroad; the number of students completing secondary education and prepared for post-secondary study; the extent to which home countries are “supply constrained” in the availability of comparable quality higher education; 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.⁵

The 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 form of fellowships, teaching assistantships, and research awards, foreign undergraduates are generally expected to make full tuition payments. Administrative data on F-1 visa recipients from China illustrates his point: for the 2010-15 period, only 3.5% of total funding for undergraduate students from China was from the universities they attended.

A very small number of 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. With a fourfold increase in China’s GDP per capita between 1996 and 2012, we calculate that while less than 0.005% of Chinese families had incomes greater than 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% of families were predicted to have such incomes.⁶ In

⁵ 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. Bound, Demirci, Khanna and Turner (2014) show that a large fraction (at least 70%) of the graduating class of F-1 visas transition to work visas (H1-Bs or OPTs) within the year after graduation.

⁶ 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

Figure 2 we show how this fraction closely tracks the fraction of college-age Chinese students studying in the U.S. While some of the students from China studying in the U.S. are from 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 of this generation have a single child, reflecting the one child policy in many parts of China, and may concentrate their investments in the single child.

Beyond the obvious observation that China and India are large countries, they are also countries where secondary education has grown dramatically. Between 1996 and 2012, secondary enrollment in India increased 78.8%, from 66.6 million students to 119 million, and in China by 48.9%, from 63.8 million students to 95 million (UNESCO).

Availability of home country higher education options is another factor affecting whether students pursue enrollment in the U.S. Indeed, there are significant differences across countries in measures of supply, defined simply as the number of institutions relative to population. While China has roughly four times the population of the U.S., it has less than half the number of higher education institutions – China has 912 and the U.S. has 2022 institutions listed in the World Higher Education Database. There are also significant differences across countries in the supply of relatively resource intensive universities. The U.K. and Canada have university options comparable in quality and resource intensity to those available in the U.S., except perhaps among the wealthiest private universities and liberal arts colleges.

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 opportunities – is greater than for the most elite private universities in the U.S. (LaFraniere, 2009). These higher education supply constraints motivate foreign students to seek enrollment in the U.S., as well as other countries with well-developed higher education sectors such as the U.K. and Australia.

One implication, which is broadly supported by descriptive tabulations, is that there will be substantial differences across countries in the concentration of students at different types of colleges and universities in the U.S. Students who come from countries that are most supply

distribution. 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.

constrained are likely to consider a much wider range of institutional options in the U.S. than those who come from countries where university options are nearly as diverse and plentiful as in the U.S.⁷ Figure 3 uses administrative data on F-1 visa recipients enrolled at U.S. undergraduate institutions to show the distribution of students from China among institutions of different levels of academic selectivity, distinguishing between public and private institutions. Students from China are concentrated at strong public research universities, which tend to be somewhat less selective than the very top private research universities in the U.S. The concentration of Chinese students at these public universities reflects their scale, and that there are few institutions in China of comparable quality to public American research universities.⁸

Between 2007 and 2012, public research universities experienced a 112% increase in freshman foreign undergraduate enrollment, while private research universities experienced a 61% increase. The observation that students from China have chosen to enroll at the public universities in large numbers motivates our consideration of why these institutions have accommodated the growth in demand from foreign students.

Section 2. Market Structure and Resources for Higher Education in the U.S.

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. Sources of support differ with institutional control. While private institutions rely on tuition revenues and (among the elite) endowment returns, public universities draw on state subsidies and tuition revenues with a more modest role for endowment returns. 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.⁹ While some research universities enroll

⁷ Bound, Turner and Walsh (2009) largely find this result at the doctorate level, where students from countries like China attended a much broader range of institutions than those from Canada and European countries like the U.K. and France who tended to be concentrated in very top U.S. universities.

⁸ Since the late 1990s there has been an expansion in the supply-side of the non-selective universities in China, within which enrollment increased from 3.1 to 20 million in approximately 10 years. Since Chinese students would have opportunities to enroll in comprehensive-level institutions in their home countries at a fraction of the cost, we see almost no Chinese enrollment in non-research U.S. universities.

⁹ 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. News and World Report rankings; these include the University of California, Berkeley, UCLA, University of Michigan-Ann Arbor, University of Virginia, and University of North Carolina-Chapel Hill.

students from across the nation and the world, the majority of public colleges and universities draw students primarily from local or regional markets. In exchange for funds provided by the state government, 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.¹⁰

Within states, there is significant stratification and specialization among the public institutions. Generally, at least one institution, often referred to as the “flagship university”, has a mission which includes research and doctoral education. States also support colleges and universities that are more regional in orientation and focused on providing undergraduate education and professionally-oriented master’s programs, often with a vocational and technical orientation that would be atypical at a research university.

2.1 Trends in U.S. Higher Education

For public universities, 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 4 shows state appropriations per full-time equivalent (FTE) student at public colleges and universities over the last 30 years. In 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. The secular decline is punctuated by clear downward cycles following recessions in 1990, 2001, and 2008.

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 in which public institutions raised

¹⁰ 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.

tuition the most, with in-state tuition increases greatest at the flagship and more selective institutions within each state (Barr and Turner, 2013).

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. Yet, higher education policy experts have recognized that the “demand” from well-qualified domestic out-of-state students is modest, particularly for those public institutions that do not compete with top private universities.¹¹ At the same time, the pool of well-qualified students from abroad is growing and is increasingly able to afford a U.S. education as incomes in emerging economies have risen. This growing pool would allow some public universities to use foreign enrollment as an important tool in recovering lost state appropriations while maintaining admissions criteria.

Indeed, our descriptive evidence presented in Table 1 underscores these basic points about revenue sources and the flow of students from different geographies. We focus our analysis on public universities, and we distinguish universities by the scope and scale of their activities, including doctorate education and sponsored research.¹² The columns of the table present different public university categorizations (Research, Flagship, AAU, and Non-Research), with the AAU set representing the most-resource intensive and selective public universities, while the top and bottom panels show measures for 2007 and 2012, respectively. Across all institutional categories we see a rise in tuition revenue and a decline in state appropriations, with this change largest among the AAU universities. 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. It is also the case that tuition levels increased, with the greatest percentage change for in-state students. Concurrently, we see

¹¹ Indiana University Professor Don Hossler notes: “There cannot possibly be enough students with the means and 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). There is considerable variation in the extent to which public universities 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, and the University of Iowa.

¹² Specifically, these are the 138 public doctorate granting universities which are high or very high research activity according to the 2010 Carnegie definition, which includes public universities with substantial federal research support.

dramatic changes in the representation of students from abroad (outside the non-research universities) and largely insignificant changes in the number of domestic out-of-state students. On the other hand, non-research four-year institutions enrolled a small number of foreign students in 2007 with only modest additions by 2012, even as enrollment increased overall.

2.2 A Conceptual Framework of a Public University Decision to Enroll Foreign Students

A full model, detailed in the appendix, describes the behavior of public universities and state legislators, each with different objective functions captured in a principal-agent problem. In our model, we show that even if the primary concern of universities is with the quality of education they provide, and state legislatures are only concerned with enrolling more in-state students, universities will still enroll out-of-state tuition-paying students when faced with funding declines. We model quality of education as a function of the ability of the student body, as well as educational expenditures per student. The university faces a given pool of applicants with heterogeneous abilities from within the state, out-of-state, and from abroad. Public university revenues come from tuitions and state appropriations. In-state students pay in-state tuition and out-of-state and foreign students pay out-of-state tuition. State appropriations are a contract determined by the state legislature as an increasing function of the enrollment of in-state students.

First, state legislatures focus on the number of in-state students enrolled in the public university as well as their capacity to provide other public goods to the rest of the population. In equilibrium, appropriations increase with state revenues – motivating our empirical identification strategy. Then, to maximize the quality of education provided, the public university makes choices on the number of in-state, out-of-state, and foreign students to enroll and how much to invest in education. In equilibrium, public universities enroll foreign students to the extent that they pay higher tuition, effectively increasing the educational subsidy of in-state students. When state appropriations decline, public universities are more likely to admit foreign students because the marginal benefit of additional foreign students (and the associated tuition revenues) increases.¹³

¹³ As we discuss in the appendix, these results hold even if the university's objective function values enrolling additional in-state students in levels, not just shares.

Our model formalizes a simple point: even if the primary concern of public universities is the education of state residents (as enforced by state legislatures), state universities will have an incentive to enroll well-qualified out-of-state and foreign students to effectively subsidize the education of the in-state students. Drops in state appropriations will increase the value of out-of-state and foreign students.

2.3 University Heterogeneity: Research vs Non-Research Universities

Our model explains the heterogeneity in enrollment of foreign students by accounting for systematic differences among universities in the supply of high-quality applicants. In particular, our model predicts that very selective research universities, such as the University of Michigan or the University of California-Berkeley, have access to a substantial pool of high quality out-of-state domestic students. Other research universities, such as Michigan State University or UC Davis, have access to a large pool of high-quality foreign applicants, but face a rapid decrease in out-of-state applicant quality as they expand enrollment. Our model predicts that such universities will not only have high foreign enrollment relative to out-of-state enrollment, but will also adjust to appropriations shocks by further increasing foreign enrollment. Indeed, declines in appropriations in the state of Michigan produce little change in foreign enrollment for the University of Michigan but a sharp increase at Michigan State (Appendix Figure A1). The University of Michigan is distinguished because, at the baseline, out-of-state enrollment among domestic students was quite high and revenue from state appropriation a relatively small share of total expenditures. A consistent pattern is observed in California, a state that traditionally had strong support for higher education but recently experienced a substantial decline in appropriations. 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 the rise in foreign students far exceeds the rise in out-of-state student. Finally, we expect that smaller, regional, non-research universities, such as Eastern Michigan University, have limited access to out-of-state and foreign student applicants. Across the California State universities, out-of-state domestic enrollment is miniscule (less than 400 students), while enrollment of foreign students is modest (less than 5% of total first-time enrollment).

We test these predictions at the university level, using the variation from state budgetary shocks. Consistent with the results predicted by the model, the empirical analysis shows that the

rise in foreign enrollment is, indeed, driven by falling state appropriations and concentrated in research universities with limited access to out-of-state domestic students.

Section 3. Empirical Framework

Our empirical approach focuses, first, on regressions that show the link between changes in state appropriations and enrollment by domicile, distinguishing in-state students, foreign students and out-of-state students. Our underlying hypothesis is that while the increase in foreign demand for U.S. undergraduate education could affect enrollment in all public research universities, universities suffering appropriation cuts are the ones overwhelmingly enrolling foreign students. Then, we turn to the consideration of how institutional adjustments in finances, including tuition revenues and expenditure categories, adjust to changes in state appropriations. In this setup, we address the concern that institution-level changes in appropriations are endogenous by using an instrumental variables strategy that draws on state budget mechanics. Data used in this analysis come from multiple institutional surveys of colleges and universities, as well as administrative data on foreign students studying in the U.S. with student F-visas.

3.1 Estimation Model

We use a panel of institutional observations for public universities and regress university-level outcomes on appropriations, cohort size, and state economic conditions. Observations are at the level of the university (i) and the year (t), and our preferred specification is:

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

where y_{it} is the outcome of interest, App_{it} represents institutional level appropriations, X_{it} are state-level time-varying controls, and γ_t and δ_i are year- and institution-specific fixed effects, respectively. The variation we use is therefore unaffected by secular changes in the entire economy and institution-specific time-invariant characteristics. The year fixed effects control for the overall increase in the demand for a college-education from domestic and foreign applicants, with year fixed effects in specifications for each group of universities accounting for overall changes in demand for universities in the group. Among the state-level controls is a measure of the population at age 18, which may capture institutional capacity.¹⁴ Evidence indicates that

¹⁴ 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

college-age populations strongly drive in-state enrollment patterns (Bound and Turner, 2007). We use the basic specification to study the effects of state appropriations on enrollment of foreign, in-state and out-of-state students and the finance variables, such as instructional expenditures and tuition levels. In the specification we report, our institution-year observations are weighted by the undergraduate population at baseline (1996).¹⁵

There are a few reasons why an OLS regression might not capture the causal effect of state appropriations on the outcomes of interest, particularly foreign enrollment. First, there may be unobserved university characteristics correlated with foreign enrollment and state funding. For instance, a successful university administrator might make qualitative changes (such as a curricular reorganization) that both affect the university's desirability for foreign students and state legislators' willingness to provide state funding to the university. Second, if state legislators punish schools that enroll more foreigners by cutting their funding, there may be a reverse causality problem. Last, growing universities may see concurrent increases in both their funding and the number of foreign students.

In order to address these potential endogeneity issues, we use variation in appropriations at the *state level*. The higher education budget is often described as a “balance wheel” of state budgets as many states determine the amount of appropriations to colleges and universities by what is left over after other spending priorities (Bell, 2008). The variation in higher education budgets is derived from the interplay between a state's revenue cycle and spending obligations. This interpretation is consistent with the literature which indicates that a major determinant of state appropriations is the cyclical pressures from federal programs with state-level matching features, like Medicaid (Kane, Orszag and Apostolov, 2005).

State-level appropriations might be problematic if, for example, employment growth in a state both boosts state budgets and effects enrollment decision of domestic in-state or out-of-state

increases in the college-age population. For example, from 1970 to 2004, college-age populations declined in Iowa (-22%), Indiana (-13%), Ohio (-18%), and Michigan (-15%), while they increased substantially in Florida (+99%), Texas (+56%), California (+42%) and Georgia (+41%). 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. 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.

¹⁵ We show in Appendix Table A4 that our results are robust to not weighting the regressions.

students, which might feed back into less need or room for foreign students.¹⁶ We provide evidence that this is not an issue in our empirical framework. We demonstrate that our main results are unaffected, and often stronger, by the inclusions of a rich set of controls: the state unemployment rate, the share of the population below the poverty line, an indicator for whether the governor is a Democrat, the rate of non-farm employment growth, the population at age 18 for all neighboring states, the state level personal income per capita, median wages of employed workers with at least a bachelor degree for ages 23-35, for ages 36-49, and for ages 50-60. While it is natural to worry about the possibility that unobserved factors might be biasing our estimates, adding additional controls tends to have little effect on estimated effects.¹⁷

We show that these trends are not driven by international student preferences: foreign students are *not* more likely to attend private universities in states suffering economic-downturn driven state appropriation cuts. Our results are stronger when we exclude the state of California that has historically had a disproportionately high Asian population.

We also explore additional instruments. The first strategy reflects differential dependence on state appropriations among universities within the same state. For instance, in 1996, state appropriations reflected more than 50% of the educational expenditures budget for each of the University of California campuses, while appropriations provided 13% of education expenditures at the University of Virginia, and 17% at the University of Michigan. Following Deming and Walters' (2017) analysis of attainment at broad access post-secondary institutions, we also construct an instrument using the product of the baseline budget share of appropriations and the aggregate state level appropriations for higher education (Appendix Table A5). These results are consistent with our baseline estimates.

Second, we use a state's disposable revenue (general revenue net of entitlements) as an instrument for the university level appropriations. While state legislators might receive some pressure from universities and the higher education community in the determination of state higher education budgets, the state's disposable revenue is likely defined by factors orthogonal to

¹⁶ McHugh and Morgan (1984) and Kennan (2015) document the migration of domestic students across U.S. states based on employment growth and expected lifetime income, and these time varying controls may help account for changes in state-level economies.

¹⁷ Here it is worth noting that the bias in IV estimates due to specification error will be inversely proportional to strength of the first stage (Bound, Jaeger and Baker, 1995; Conley, Hansen, Rossi, 2012). Budgetary shortfalls experienced by states over the period of our study produce substantial variation within states over time in the overall state appropriations variable used as an instrument.

the university needs, such as the state tax code and generosity of Medicaid program. Finally, we use appropriations assigned to all other universities in the state (state level appropriations minus university own appropriations). This instrument addresses the concern that big universities might represent a substantial share of state level appropriations in smaller states. All results are consistent with our main specification.

Even though we do not model the dynamic response of universities to changes in state appropriations, some lag in the enrollment response is expected as it takes admissions offices time to gear up to evaluate foreign applicants. At the same time, most of the variation in the state appropriations measure we use as an instrument is of low frequency and our fixed effect estimators are designed to reflect this variation.¹⁸ As such, our estimates should be interpreted as reflecting the behavior of state universities in the presence of persistent appropriation changes. We also explore a distributed leads and lags model and find that appropriation changes in the future have no effect on current foreign enrollment, negating concerns of reverse causality. We also find that current reductions in appropriations raise foreign enrollment, in both an economically and statistically significant manner, for two years after the change in appropriations.¹⁹

3.2 Data Sources

Data on annual enrollments, degrees conferred, and finance variables for each college and university are collected through several sources, the details of which are discussed in the appendix. 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 awarded. We focus our main analytics on the period from 1996-2012 (where 1996 corresponds to the 1996-97 academic year), as this is the interval in which there is a large, qualified 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,

¹⁸ We employ Fourier decomposition methods following Baker, Benjamin, and Stanger (1999) to analyze the time series properties of our state-level appropriation measure. We find that over 70% of the variance occurs at the lowest two frequencies identified in the data.

¹⁹ These additional results are available upon request.

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.*” 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.²⁰ In order to reduce the incidence of missing data, we complement our dataset with enrollment information from the Common Dataset Initiative and the University of California System when this information is missing in the ASC.

In addition, we employ the universe of F-1 visa recipients (2004-2015) which provides individual level data identifying each student’s intended degree, subject of study, post-secondary institution in the U.S., city and country of origin, along with variables indicating cost of attendance, financial support, and beginning-end dates of the period of study. These data align well with the IPEDS data and they allow us to distinguish foreign students by country of origin.

Section 4. Empirical Results

4.1 Effects of State Appropriations on Foreign Enrollment

The questions motivating our analysis concern how declines in state appropriations are accommodated by changes in the composition of undergraduate enrollment across the public sector given the expansion of the pool of foreign students in recent decades. Institution-level regressions of total first-time foreign enrollment on appropriations, including additional institutional and time-varying effects, are shown in Table 2 for the period 1996-2012. We present these results for two main groupings of institutions: public research universities, and public universities outside the research sector. We also report results for Flagship and AAU

²⁰ 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.

universities, although their results are similar to the all research universities group. Enrollment measures are derived from institution-level surveys from the ASC. Recognizing the concern that appropriations changes may be endogenously related to other institution-level adjustments affecting the composition of enrollment, we focus on the estimates using total state appropriations to higher education as an instrument for the institution-level measure (with the first-stage estimates in the bottom panel). We include the OLS estimates for comparison.

There is a strong, consistent, and negative link between appropriations changes and the enrollment of foreign students at public research universities (but no such link outside this sector during this interval). With a specification in logs, we find that a 10% decline in state appropriations corresponds to an 11.7% increase in the representation of foreign students at the undergraduate level across all research universities. As a point of reference, the OLS results tell a similar story with somewhat attenuated point estimates (the difference between OLS and IV is never close to statistically significant). These estimates imply that the drop in appropriations state universities experienced over the 2000-2012 period can explain just over 50% of the increase in the representation for foreign students at AAU universities, 35% of the increase for flagship universities, and just under 30% of the increase at research universities.²¹

In Table 3 we show that our main results display a slightly stronger relationship with the inclusion of state unemployment rate as a control. That the change is minor reflects the fact that domestic enrollment at selective universities are not sensitive to economic fluctuations.

The graphic presentation over the period from 2006 to 2012 in Figure 5 helps to anchor the negative relationship between total appropriations at the state level and foreign enrollment among public research universities, with a focus on the AAU institutions. While the basic negative relationship for public universities is clear, there is also a significant amount of heterogeneity. For instance, for the same state-level budgetary shock, Michigan State significantly increased foreign enrollment, while the University of Michigan did not. One reason is that the University of Michigan consistently attracts well qualified domestic out-of-state students (around 30% of total freshmen), whereas MSU does not (only 10% of total freshmen).

²¹ To calculate the fraction explained for each university sub-group over the period, we take the product of the estimated coefficient and the average change in appropriations, and divide this predicted change in foreign enrollment by the total actual change in foreign enrollment.

Also shown in Figure 5 is the specification check provided by the private institutions. If foreign students had state-specific preferences, one might expect to see a parallel response in private peer institutions; yet, what little relationship is visible is of the opposite sign (regression results using state level appropriation on foreign enrollment at private universities in Appendix Table A3).

4.2 Alternative Specifications

A number of specification alternatives confirm the tenor of these results and, in the interest of parsimony, are presented in the appendix. First, consideration of the dependent variable as either a level (number of students) or as the foreign share among all first-time students also yield the negative relationship between appropriations and enrollment at the research institutions and little measured effect outside this sector (Appendix Table A1). Secondly, we are able to use the micro-data from the F-visa issuances to estimate these specifications with a distinction by country of origin over the shorter interval from 2004 to 2012. Our results are not only remarkably consistent with the baseline results presented in Table 2, but also provide strong confirmation that the role of the expanding pool of Chinese students is central to this adjustment mechanism. The estimated enrollment elasticity for Chinese students is about -2.1 at all research university and indistinguishable from zero at the non-research institutions (Appendix Table A2). Thirdly, we demonstrate that our results are robust to the inclusion of the long list of state-level controls discussed in section 3.2, which are correlated with state economic activity (Appendix Table A4).

Our main relationship is unaffected when we control for a university's foreign enrollment level in the early years of our sample. Indeed, the coefficient on the baseline number of foreign students is economically and statistically negligible, implying that schools with an initial high foreign enrollment are not responding more strongly to appropriation cuts during the foreign enrollment bust of the late 2000s. Also, our results from Table 2 are unaffected when we drop California schools. California is the state with the biggest East Asian and Chinese population in the U.S. and these schools may benefit the most from the increase in family incomes in China. We estimate an even stronger relationship between state appropriations and foreign enrollment for research universities when we exclude California schools from our sample.

Finally, we explore alternative instrumental variables strategies to solidify our approach. In Appendix Table A5 Panel A, we first use state level appropriations interacted with the university specific revenue dependence on appropriations in 1996, given that appropriations cuts are more likely to have a greater proportionate impact on institutions that rely more on state appropriations (Deming and Walters 2017). The results from this estimation are consistent with the main findings of the paper presented in Table 2. In Panel B, we use the state's general revenue net of entitlements as an instrument for university-level appropriations, consistent with the notion that state budgetary cycles are driving the variation in question. State disposable revenues are likely orthogonal to political pressure for increasing in higher education funding, potentially correlated to foreign enrollment. While this instrument displays a weaker first stage, the results are consistent with our main specification. Lastly, in Panel C we use appropriations assigned to all other universities in the state minus university own appropriations as an instrument to universities own appropriations. Again, all the results are in accordance with the finding that research universities increase foreign enrollment as a response to decline in appropriations.

Overall, these findings are consistent with our underlying hypothesis and conceptual framework: 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. Given the increases in demand from foreign students for positions in U.S. universities, it seems likely that foreign enrolment rates at U.S. public universities would have increased significantly even were it not for the drop in state appropriations that has occurred over the last 15 years. However, the evidence we have presented is consistent with the notion that the growth would have been substantially less dramatic had it not been for the drop in appropriations state universities experienced. 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 more locally focused than the research universities, and have limited capacity to attract foreign students.

4.3 Effects on Domestic In-State and Out-of-State Enrollment

In addition to increasing the representation of students from abroad, universities might respond to appropriations changes with other adjustments to undergraduate enrollment on the margins of in-state and out-of-state enrollment. Table 4 considers these specifications in parallel format to Table 2. The overall story line is that there appears to be little adjustment on these margins, with coefficients on appropriations that are statistically indistinguishable from zero and, overall, small in magnitude. The absence of an effect on out-of-state domestic students, another source of revenue from out-of-state tuition, is consistent with the proposition that the supply of academically-qualified, domestic full-pay students at the enrollment margin for most public universities is modest. Also, given these results, we have no reason to expect that any changes in foreign enrollment are driven by changes to domestic enrollment in the wake of falling appropriations.

It is important to emphasize that our results focus on initial undergraduate enrollment at 4-year universities, which represent a subset of all public post-secondary institutions.²² A recent paper by Deming and Walters (2017) presents estimates of a negative effect of changes in state appropriations on total enrollment, with the measure of total enrollment defined for all levels of enrollment and the estimates presented for all post-secondary institutions (including community colleges). Results in other work (Bound and Turner, 2007; Barr and Turner 2013) show that the accommodation of resource changes and cyclical student demand differ markedly across post-secondary institutions, with open access public institutions including community colleges demonstrating the greater supply-side elasticity in enrollment than research universities.²³ To this end, economic theory and available empirical evidence suggest that changes in state appropriations for higher education may have impacts on domestic enrollment in other contexts including community colleges and among older students.

Focusing on public research universities, we find that within this group there is heterogeneity in the response in foreign enrollment to appropriations changes that is related to institutional selectivity, research intensity, and scope of domestic market (Table 5). First, public

²² Using the 2010 Carnegie classification, we define research universities as the categories “Very high research activity” and “High research activity” while the non-research universities include those classified as “Doctoral” and “Masters” universities. Not included in our analysis are specialized institutions or local degree-granting institutions classified as “Baccalaureate.” Our aim in choosing the institutional types for analysis is to group institutions that might be expected to follow broadly similar production functions.

²³ Barr and Turner (2013) show that local economic conditions (such as the unemployment rate) have a substantial impact on enrollment at community colleges, with such changes in enrollment including substantial increases in the participation of students older than recent high school graduates.

research universities with higher baseline Math SAT scores have the ability to attract qualified students from abroad. Second, universities that spend a larger fraction of their total expenditures on research-related activities, at baseline, also do a better job of accommodating a fall in funds with enrolling more foreign students. Last, we explore heterogeneity along the baseline ability to attract domestic out-of-state students. Here we expect that the universities that most aggressively pursue foreign students will be those outside the very top tier that are capable of attracting a substantial number of domestic out-of-state students. While the contrasts in these last set of columns are not precisely estimated, this is exactly the pattern that emerges. Our interpretation of these results is that universities that have a very low baseline attraction for domestic out-of-state students find it difficult to recruit students from abroad. Consistent with the conceptual framework discussed in section 2.2, those with a very high baseline ability to enroll full paying domestic students find it less necessary to look abroad when they can recruit these students from other states. It is, therefore, in the universities that lie in-between that we see the strongest associations between declining appropriations and rising foreign enrollment.

While a common question that follows from observation of the growth in the enrollment of foreign students is whether these students “crowd out” domestic students (Machin and Murphy, 2015), the declines in the appropriations that are the focus of this analysis affect in-state tuition charges. Thus, any correlational relationship between foreign enrollment and in-state enrollment represents the net effect of changes in tuition charges, institutional resources and other unobserved factors, as well as the direct effect of foreign students. With these limitations in mind, in Appendix Table A6, we show a negative association between the number of foreign students enrolled and the number of in-state students enrolled in Research and AAU universities. Two additional foreign students are associated with one less in-state student. While these estimates should not be interpreted as causal, our model suggests that crowd out effects can occur even when university administrators care only about the quantity and quality of the education in state residents obtain.

4.4 State Appropriations and University Finances

Changes in state appropriations directly affect university budget constraints. 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

education. Our interest is in understanding how such effects may be moderated by other channels of adjustment – either changing the composition of student enrollment by expanding the matriculation of foreign students or increasing the tuition charged.

As shown in the top panel of Table 6, there is a positive relationship between changes in state appropriations and expenditures on instructional activities. While not presented in the tables, we find similar positive but often imprecisely estimated effects of state appropriations on other types of expenditure, such as research spending. Shifting from the expenditures side of the ledger to the revenue side, we consider how the change in the composition of the entering class, combined with changes in tuition, affects tuition revenues across public universities. These results are displayed in the bottom panel of Table 6. In the AAU sample, there is a clear negative relationship between appropriations and tuition revenues, while effects for the other samples are not precisely estimated. With the exception of the AAU sample, we find negative but not statistically significant effects of appropriations on tuition revenues. These smaller effects can be explained by a decline in full time enrollment associated with appropriations cuts, as we indeed find a strong negative effect of appropriations on tuition revenue per FTE (not presented in table).

While adding foreign students is one strategy to replace revenue lost from declining state appropriations, an alternative strategy is to increase tuition. As discussed in the earlier sections, we expect universities to have considerably more market power with in-state students than with out-of-state students. To this end, it is not surprising that there is a clear negative link between the in-state price and state appropriations, while there is no clear statistical connection between out-of-state charges and state appropriations, reflecting the constraints of the market.²⁴

There is heterogeneity in how universities responded to appropriations cuts; this variation is represented graphically in Figure 6. The figure shows how changes in appropriations over the recession affected total tuition revenues and posted rates across universities. For instance, California and Michigan schools that were especially hurt by budgetary shocks accommodated

²⁴ The greater changes in in-state relative to out-of-state tuition levels likely reflect the observation that universities 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.

these reductions by raising tuition revenues, either via enrolling more foreign students (MSU), or raising in-state tuitions (Berkeley).

A different framework for viewing these results is with tuition revenues as the dependent variable and enrollment (in levels) as the key explanatory variable. 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. We find that foreign undergraduate students generate additional revenue fairly closely aligned with the average “sticker price” of out-of-state tuition (see Appendix Table A7). 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.

Importantly, having access to a ready pool of foreign students may mute increases in in-state tuition rates or cuts to expenditures.²⁵ We show some suggestive evidence in support of this. In times when there were more foreign students who were able to afford tuitions charged by U.S. institutions (2005 onwards), the responsiveness of tuition rates and expenditures to appropriations is smaller (Appendix Table A8). However, since there may be other differences across the two time periods, this type of heterogeneity analysis should be taken to be suggestive rather than conclusive.

4.5 Heterogeneity and Adjustment Channels to Appropriation Changes

Our results demonstrate the clear link between changes in state appropriations and changes in the flow of students from abroad and the price charged to in-state students as primary channels through which universities moderate changes to state appropriations. The capacity to reduce the impact of appropriation changes varies with an institution’s market place: those universities with national and international recognition have the capacity to increase the intake of foreign (and, potentially, out-of-state) students while also potentially increasing tuition charges.

Still, we expect that political considerations which impact appropriations place some limits on how even the strongest universities can maneuver in this space. Local and regional

²⁵ Shih (2017) finds evidence suggesting that the expansion in enrollment of *graduate* students from abroad contributes to growth in domestic student enrollment with these effects largest at institutions with high relative tuition paid by students from abroad.

institutions likely have fewer options to the extent that there is little foreign (or out-of-state) demand while comparable within-state alternatives may limit tuition changes.

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:

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

where D_t is the difference between in-state and out-of-state tuition, s_o is the 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, 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 7 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 make up 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.²⁶

This accounting exercise reflects the relative importance of changes in tuition 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 69% of the change in tuition revenues, as show in the fifth column of Table 7. On the other hand, increasing domestic out-of-state enrollment is an

²⁶ 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.

important method of adjustment for certain schools like Colorado-Boulder, Oregon, and Pittsburgh.

Turning to the role of the change in foreign student enrollment, shown in the first column of Table 7, we find that the increase in foreign students accounts for about 17.4% of the increase in tuition revenues, on average. Notably, for a modest number of universities (such as Minnesota, Purdue, and Ohio State) the change in foreign student enrollment accounts for 40% or more of the change in tuition revenues over the interval.

Section 5. Conclusion

Concurrent with the erosion of state support for public higher education (which has occurred to different degrees across the U.S.) there has been a substantial increase in the pool of students from abroad who are academically college-ready and have the financial capacity to enroll. In many developing countries, and most notably China, home country options for post-secondary study at the research university-level are far more limited than student demand. In the aggregate, there is no question that U.S. colleges and universities have absorbed some of this increase in demand with the evident growth in undergraduate enrollment among temporary residents.

What this analysis demonstrates is that within-state declines in appropriations have disproportionately affected the accommodation of the expanding pool of foreign students by U.S. colleges and universities. We estimate that a 10% reduction in state appropriations leads to a 12% increase in the enrollment of students from abroad at public research universities and a slightly larger increase of about 17% at the more resource-intensive AAU universities. There is no systematic accommodation at colleges and universities outside the research university sector. Evidence presented in this analysis suggests that expanding foreign enrollment at the undergraduate level is an important channel through which public research universities buffer changes in state appropriations. While additional revenue from in-state tuition increases appears recoup a large fraction of the fall in appropriations, 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.

Not only are the results in this analysis consistent with straightforward economic theory, but they also align with the comments of public university administrators. Writing about the

circumstances in California, president of the University of California system Janet Napolitano writes:

“California’s situation is not unique. Nearly every state in the nation has faced this Hobson’s choice, and they have all reached the same decision: *open doors to out-of-state students in order to keep the doors open for in-state students.*” Public letter from Janet Napolitano to Elaine M. Howle, California State Auditor, 2016

The capacity of public universities to use foreign enrollment as a 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 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.

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 suggest 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). Nonetheless, our research suggests that in order to provide quality education to in-state students, public universities are turning to high paying foreign students in times of systematic declines in state funding. 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				
<i>1st Undergraduate Enrollment</i>				
# 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
<i>Revenues, 2013 Constant Dollar (Thousands)</i>				
State Appropriations	\$241,331	\$397,743	\$299,145	\$57,981
Tuition Revenue	\$188,362	\$338,900	\$245,488	\$76,791
<i>Tuition Level, 2013 Constant Dollar</i>				
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				
<i>1st Undergraduate Enrollment</i>				
# 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
<i>Revenues, 2013 Constant Dollar (Thousands)</i>				
State Appropriations	\$189,867	\$298,382	\$235,151	\$47,318
Tuition Revenue	\$256,563	\$467,993	\$329,562	\$101,001
<i>Tuition Level, 2013 Constant Dollar</i>				
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. AAU institutions are also research universities. 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 2: Effects of log state appropriations on log first-time foreign enrollment, 1996-2012

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

Panel B: First Stage		Dependent Variable: Log(State Appropriations)			
Explanatory Variable	Research	AAU	Flagship	Non-Research	
Log(Total State Appropriations)	0.663 (0.082)***	0.613 (0.119)***	0.578 (0.073)***	0.771 (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. A levels-log version of this regression exists in the appendix. 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: Effects of log state appropriations on log first-time foreign enrollment, 1996-2012 – with State Unemployment Rate

Explanatory Variable	Dependent Variable: Ln Foreign 1st Year Enrollment							
	Research		AAU		Flagship		Non-Research	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Log(State Appropriations)	-0.653 (0.197)***	-1.407 (0.505)***	-0.681 (0.245)**	-1.749 (0.677)***	-0.757 (0.322)**	-1.920 (0.752)**	0.0408 (0.205)	0.550 (0.485)
Log(Population 18)	0.170 (0.407)	0.500 (0.416)	-1.156 (0.695)	-0.826 (0.645)	-0.0298 (0.462)	0.173 (0.464)	0.521 (0.664)	0.313 (0.685)
State Unemployment Rate	-0.0171 (0.0363)	-0.049 (0.039)	0.0202 (0.0561)	-0.011 (0.045)	-0.0006 (0.0405)	-0.051 (0.051)	-0.0275 (0.0260)	-0.002 (0.038)
R-squared	0.351		0.635		0.480		0.064	
Partial R-squared	0.184		0.239		0.186		0.214	
F-Test of ivs	47.35		23.24		34.92		40.28	
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 4: Effects of log state appropriations on log first-time in-state and out-of-state undergraduate enrollment, 1996-2012

Panel A		Dependent Variable: Ln Out-of-State 1st Year Enrollment						
Explanatory Variable	Research		AAU		Flagship		Non-Research	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Log(State Appropriations)	0.045 (0.135)	-0.073 (0.218)	0.095 (0.256)	-0.437 (0.413)	-0.006 (0.210)	0.418 (0.282)	-0.018 (0.134)	-0.467 (0.255)*
Log(Population 18)	-0.678 (0.233)***	-0.635 (0.286)**	-0.580 (0.521)	-0.397 (0.514)	-0.830 (0.367)**	-0.846 (0.351)**	-0.541 (0.319)*	-0.416 (0.264)
R-squared	0.248		0.231		0.320		0.041	
Panel B		Dependent Variable: Ln In-State 1st Year Enrollment						
Explanatory Variable	Research		AAU		Flagship		Non-Research	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Log(State Appropriations)	0.098 (0.052)*	0.138 (0.091)	0.053 (0.059)	-0.074 (0.085)	0.019 (0.052)	0.030 (0.105)	0.116 (0.050)**	0.054 (0.092)
Log(Population 18)	0.626 (0.096)***	0.612 (0.113)***	0.509 (0.103)***	0.552 (0.075)***	0.198 (0.140)	0.198 (0.138)	1.051 (0.151)***	1.068 (0.234)***
R-squared	0.397		0.376		0.295		0.336	
Observations	2,121		547		791		3,162	
Number of Universities	136		34		50		285	

Notes: For the first-stage of the IV regression, see Table 2. 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 5: Effects of log state appropriations on log first-time foreign undergraduate enrollment, 1996-2012, Research Universities, Heterogeneous Effects - Instrumental Variable Specification

Explanatory Variable	Dependent Variable: Ln Foreign 1st Year Enrollment						
	Math SAT 75th Percentile		Fraction of Expenditure for Research		Fraction of Students from Out of State		
	High	Low	High	Low	Low	Medium	High
Log(State Appropriations)	-1.737 (0.616)***	-0.413 (0.284)	-2.148 (0.573)***	0.249 (0.517)	-0.695 (0.994)	-1.915 (0.505)***	-1.014 (0.571)*
Log(Population 18)	0.054 (0.843)	0.060 (0.399)	0.154 (0.575)	-0.210 (0.540)	0.884 (1.024)	0.289 (0.804)	0.246 (0.319)
Observations	867	906	1,014	958	691	692	718
Number of Universities	55	57	63	63	44	45	45
Partial R-squared	0.325	0.236	0.329	0.222	0.178	0.302	0.348
F- Statistic	49.27	44.90	52.62	38.58	25.83	43.25	56.35

Note: Overall state appropriations to higher education are used as an instrument for institution-level state appropriations. Samples are defined based on baseline (1996) characteristics. High and low are defined by above or below median when sample is split in half. Low, medium and high are define by 33th percentile when sample is split in thirds. 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 state level.

Table 6: Effects of log state appropriations on university financial variables, 1996-2012- Instrumental Variable Specification

Expenditure Variable	Research	AAU	Flagship	Non-Research
Panel A1	Log(Instructional - salaries and wages)			
Log(State Appropriations)	0.210 (0.065)***	0.236 (0.110)**	0.256 (0.112)**	0.254 (0.126)**
Partial R-squared	0.272	0.311	0.323	0.246
F- Statistic	65.64	30.95	67.45	48.58
Observations	1,717	443	651	3,509
Number of Universities	126	32	47	260
Revenue Variables	Research	AAU	Flagship	Non-Research
Panel B1	Ln (In-State Tuition)			
Log(State Appropriations)	-0.288 (0.103)***	-0.416 (0.182)**	-0.270 (0.117)**	-0.327 (0.182)*
Panel B2	Ln (Out-of-State Tuition)			
Log(State Appropriations)	0.116 (0.117)	0.307 (0.209)	0.366 (0.165)**	-0.020 (0.129)
Panel B3	Log(Tuition Revenue)			
Log(State Appropriations)	-0.058 (0.122)	-0.341 (0.186)*	-0.060 (0.155)	-0.175 (0.218)
Partial R-squared	0.301	0.312	0.295	0.250
F- Statistic	113	40.52	73.76	67.80
Observations	2,172	548	823	4,630
Number of Universities	136	34	50	293

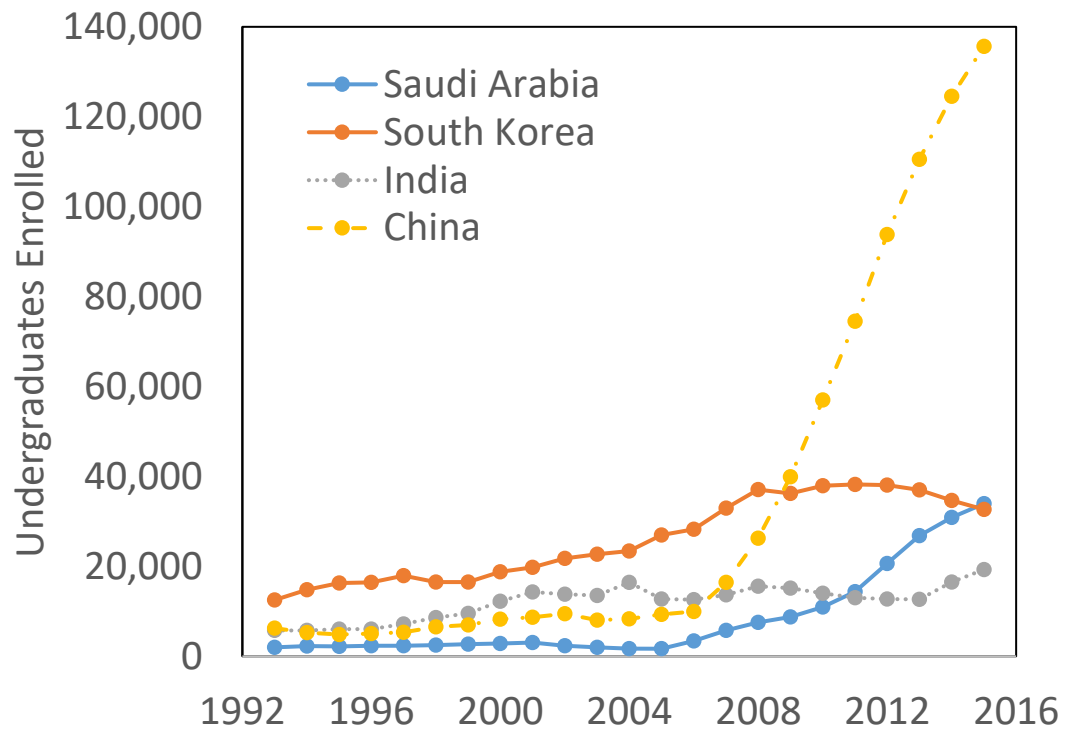
Notes: Overall state appropriations to higher education are used as an instrument for institution-level state appropriations. All regressions include institution and year fixed effects. Institution-year observations are weighted by the undergraduate population at baseline (1996). Robust standard errors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

Table 7: Decomposing per Student Changes in Tuition Revenues, 2007-2012

Institution Name	$\Delta s_f * Dt$	$\Delta s_o * Dt$	$s_f * \Delta Dt$	$s_o * \Delta Dt$	ΔT	$\Delta \left(\frac{App}{Ugrad} \right)$	$\Delta \left(\frac{Rev}{Ugrad} \right)$
University of Arizona	5.88%	-13.89%	2.46%	19.75%	85.81%	-7,642	5,302
UC-Berkeley	22.65%	0.44%	0.56%	1.19%	75.15%	-11,864	6,686
UC-Davis	8.56%	3.26%	0.29%	0.34%	87.55%	-8,871	5,647
UC-Irvine	12.54%	-3.84%	0.43%	0.34%	90.52%	-2,691	5,329
UC-Los Angeles	17.86%	12.52%	0.58%	0.57%	68.47%	-13,315	7,060
UC-San Diego	18.27%	2.50%	0.37%	0.33%	78.54%	-4,757	6,418
UC-Santa Barbara	6.55%	-0.26%	0.21%	1.47%	92.04%	-5,965	5,429
U Colorado Boulder	7.90%	28.40%	0.63%	11.77%	51.30%	-1,030	4,095
University of Florida	-0.19%	-7.20%	2.16%	9.93%	95.31%	-6,718	2,717
Georgia Tech	15.34%	-7.40%	0.89%	4.98%	86.18%	-8,682	5,004
U Illinois - UC	28.02%	-0.49%	-0.26%	-0.49%	73.22%	-1,593	4,218
Indiana University	32.01%	-35.77%	9.20%	51.53%	43.04%	-1,878	2,930
Iowa State University	24.59%	33.88%	-0.01%	-0.06%	41.60%	-4,924	1,977
University of Iowa	28.40%	8.80%	2.89%	31.62%	28.29%	-6,955	3,582
University of Kansas	12.72%	-7.64%	3.64%	22.99%	68.29%	-948	2,227
University of Maryland	30.87%	-84.28%	17.30%	155.40%	-19.28%	-559	370
University of Michigan	7.36%	6.70%	5.85%	36.07%	44.02%	-3,085	4,875
Michigan State Univ.	26.46%	1.46%	5.30%	9.80%	56.98%	-3,666	3,757
University of Minnesota	85.75%	-35.52%	-32.23%	-244.63%	326.63%	-5,713	848
University of Missouri	10.55%	56.55%	2.48%	20.98%	9.45%	-4,695	1,500
Rutgers University	9.37%	-7.43%	4.75%	17.42%	75.88%	-5,898	1,429
University at Buffalo	27.32%	-1.09%	15.85%	4.98%	52.94%	-5,790	1,947
Stony Brook University	12.09%	11.30%	9.94%	7.74%	58.92%	-8,327	1,903
Univ. North Carolina	8.01%	4.87%	1.70%	20.72%	64.70%	-5,457	2,713
Ohio State University	58.16%	4.45%	4.29%	9.97%	23.13%	-3,173	1,196
University of Oregon	13.07%	24.21%	4.72%	20.10%	37.90%	-2,694	6,931
Pennsylvania State	20.85%	15.84%	0.06%	0.45%	62.81%	-4,110	3,292
University of Pittsburgh	8.36%	27.27%	-0.42%	-5.59%	70.38%	-4,576	3,101
Texas A&M University	0.61%	-22.59%	20.40%	52.21%	49.38%	-2,139	517
U of Texas-Austin	6.23%	-0.31%	10.03%	12.76%	71.29%	-1,922	1,688
University of Virginia	6.88%	-7.11%	5.14%	31.13%	63.96%	-3,871	3,970
U of Washington	20.50%	-2.67%	-0.13%	-0.34%	82.63%	-6,934	6,572
University of Wisconsin	15.45%	4.96%	0.28%	2.21%	77.10%	-2,076	3,102
Purdue University	39.61%	2.97%	4.20%	13.65%	39.58%	-364	4,088
All AAUs	17.40%	2.79%	2.04%	8.53%	69.23%	-4,620	3,553

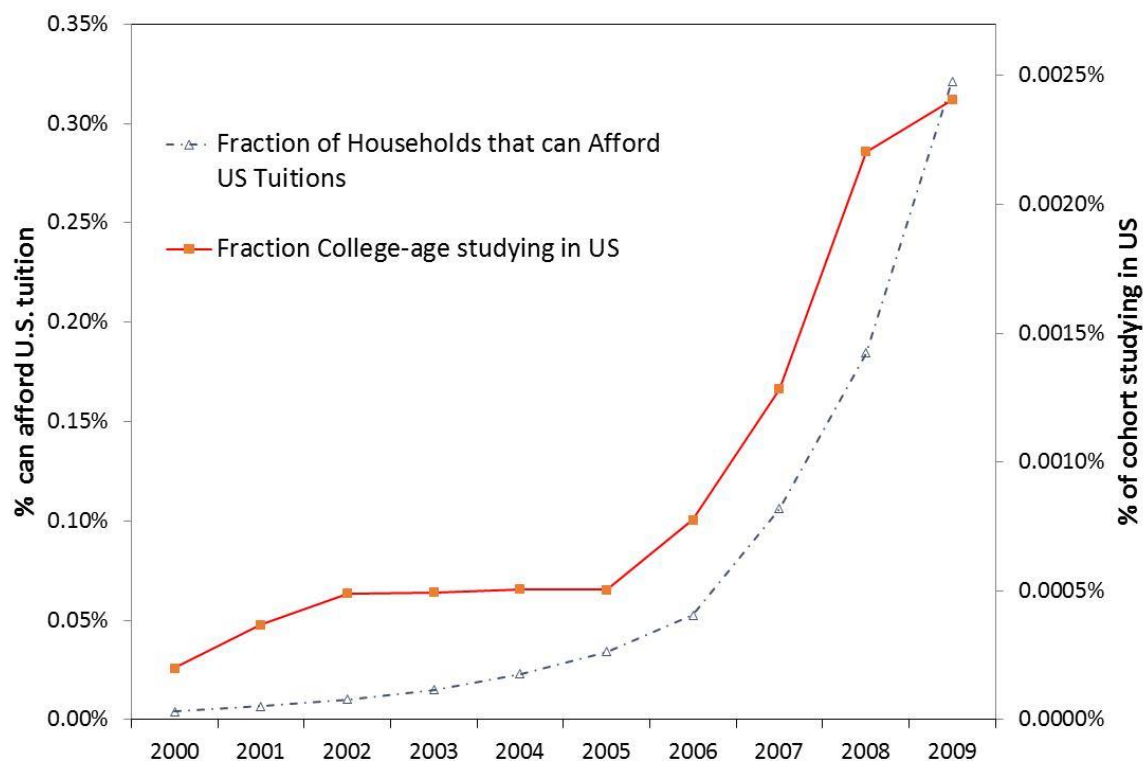
All changes are 2007 to 2012. s_f is share of undergraduate population that is nonresident alien. s_o is share of undergraduate population that is out of state domestic students. ΔT is the change in in-state tuition rates. Dt is the tuition differential between out-of-state and in-state tuitions. $\Delta \left(\frac{App}{Ugrad} \right)$ 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: Country trends in foreign undergraduate enrollment at U.S. higher education institutions, 1992-2015



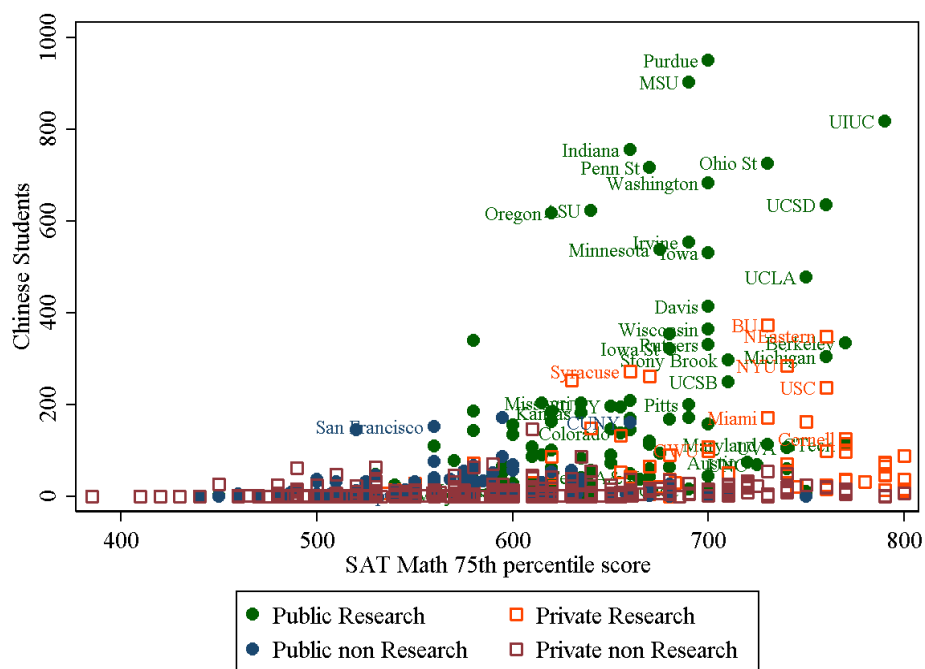
Source: *Open Doors*, Institute for International Education, various years.

Figure 2: Fraction of Chinese college-age population studying abroad and financial capacity, 2000-2009



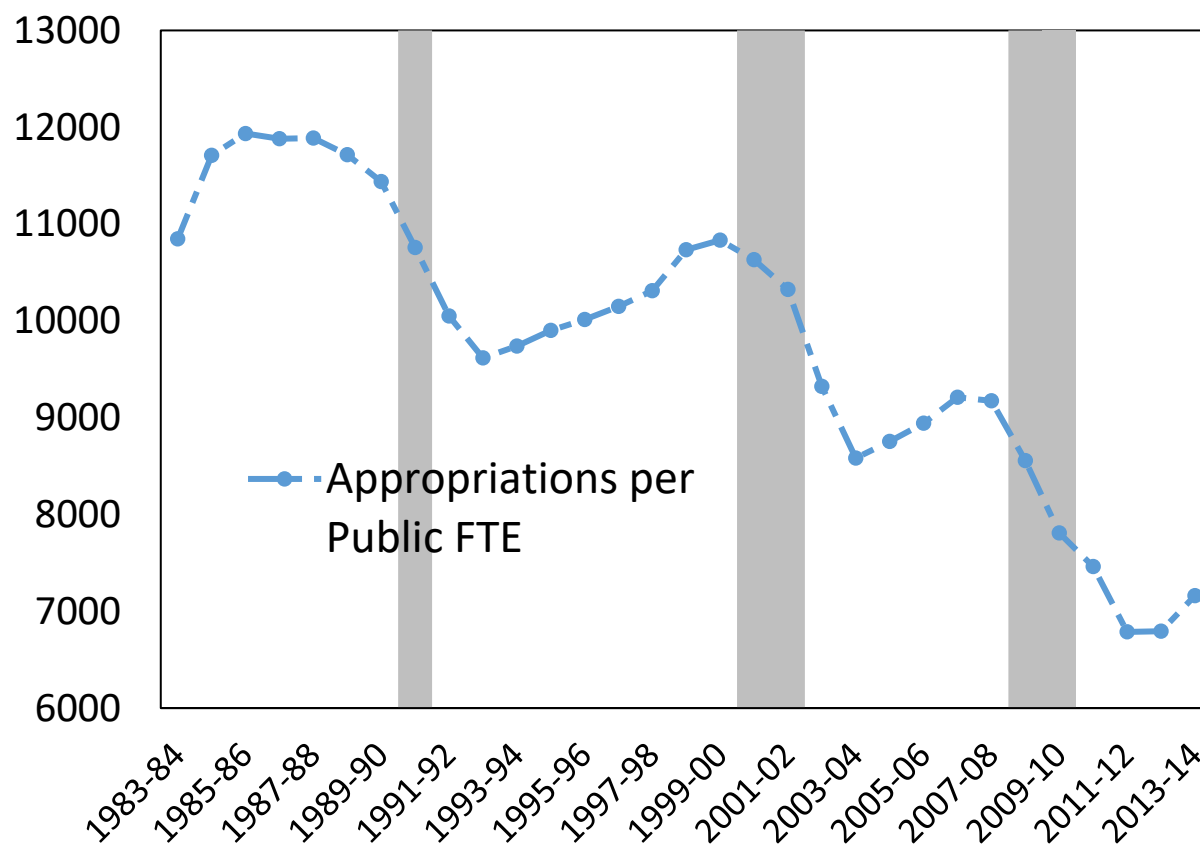
Source: Authors' calculations, based on income distribution data from the World Bank and average tuition, room and board charges for out-of-state students at public universities recorded in IPEDS. We derived the income distribution (assumed to be log-normal) following the approach of Pinkovskiy and Sala-i-Martin (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.

Figure 3: F-1 Visa Recipients for Bachelor's Degrees in China by University Selectivity (Average 2010-15)



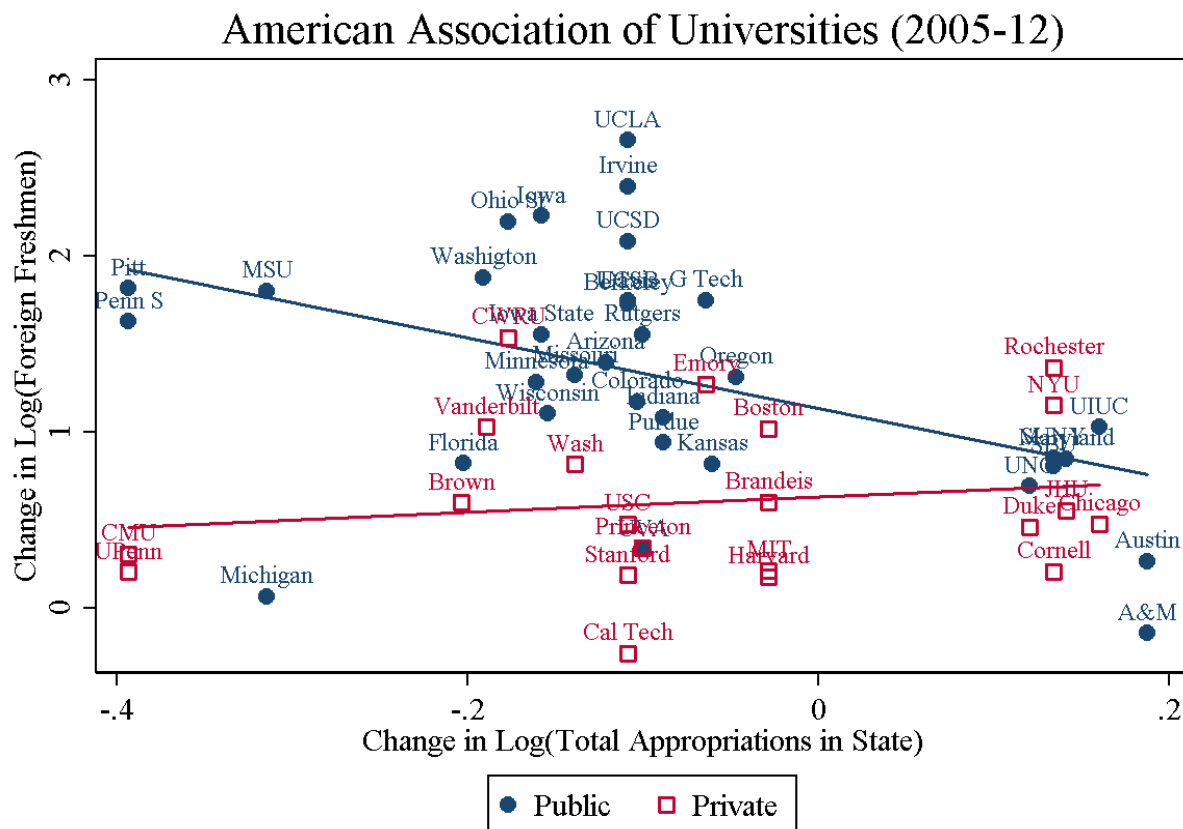
Source: F-1Administrative data

Figure 4: Appropriations per Full-Time Equivalent Student Over Time, 1983-2013



Source: *Trends in College Pricing and Digest of Education Statistics*, various years. Grey bars show US recessions as enumerated by NBER. All figures are deflated by the Higher Education Price Index (HEPI).

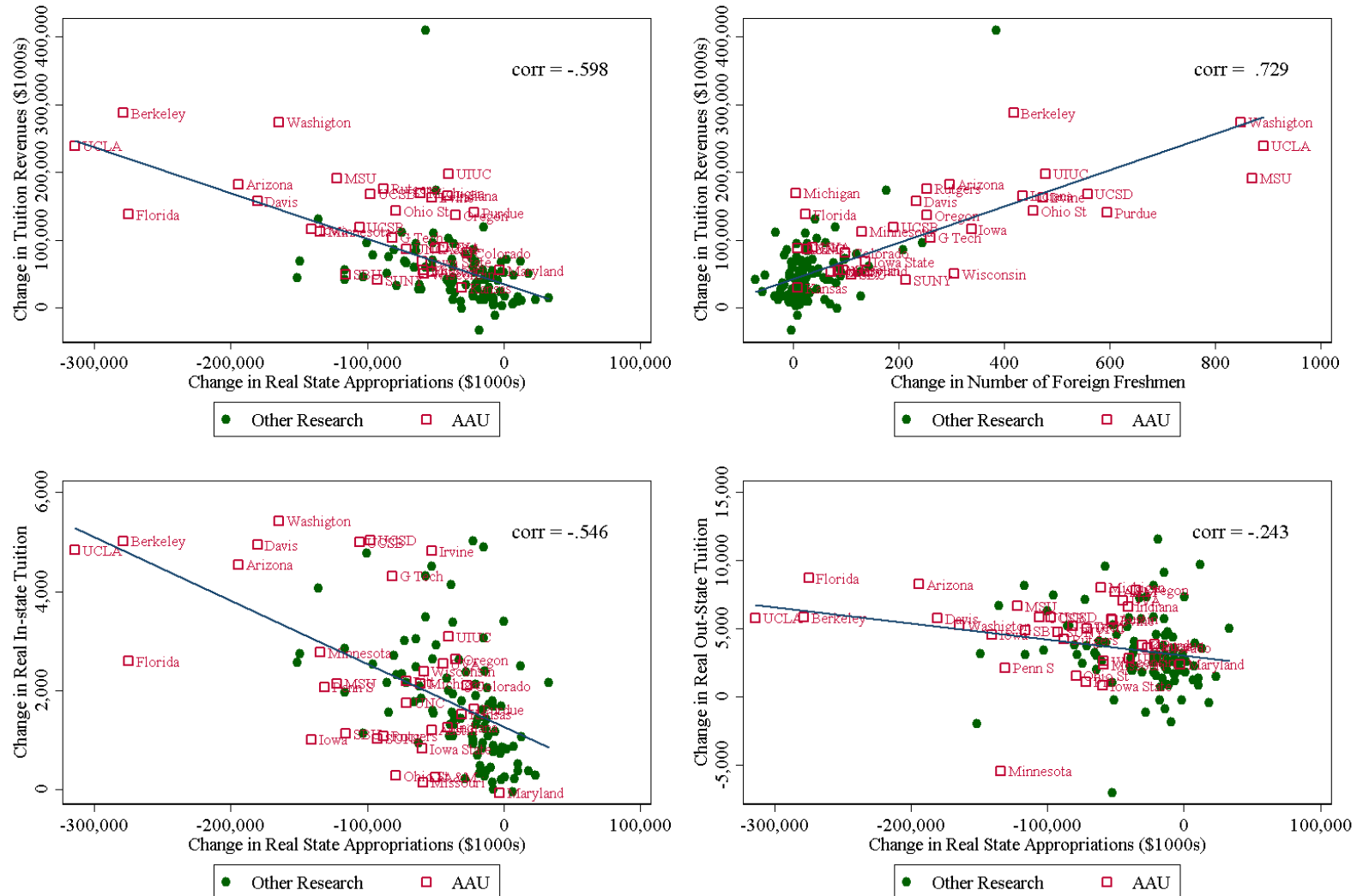
Figure 5: Foreign Enrollment and State Level Appropriations to Higher Education: AAU Private Universities, 2005-2012



Note: Sample of the 60 research universities that are part of the Association of American Universities (AAUs). Change in Log (Foreign Freshmen) are university-level changes in first-year students from abroad. Change in Log (Total Appropriations in State) are state level measures for changes in total appropriations to all public universities in the state between the financial years 2005-6 and 2012-13. Foreign Freshmen data is from ASC.

Figure 6: Change in Appropriations, Tuition, and Foreign Freshmen - 2007 to 2012

Tuition Revenues and Rates (2007-12)



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, tuition levels and tuition revenue data from IPEDS, foreign freshmen from ASC.