The Impact of International Students on US Colleges: Higher Education as a Service Export*

Mingyu Chen† Yanzun Yang‡

July 29, 2026

Abstract

Between 2003 and 2016, international enrollment in US higher education nearly doubled. We examine how trade shocks in education affect public universities' decision-making. We construct a shift-share instrument exploiting institutions' historical networks with different origins of international students, income growth, and exchange-rate fluctuations. Contrary to claims that US-born students are crowded out, we find that international students increase schools' funding via tuition payments, leading to increased in-state enrollment and lower tuition prices. Schools also maintain per-student spending and recruit students with higher math and verbal scores. Lastly, states allocate more appropriations to (research) universities that attract fewer international students.

Keywords: Higher education, international student, university objective, service trade, education export

JEL Codes: I21, I23, F14, F22, J61

*This paper was developed from Mingyu Chen's third-year paper at Princeton University under the generous guidance of Henry Farber. We are particularly grateful for the support of Alan Krueger, who provided indispensable encouragement on this project. We thank Jesse Bruhn, Leah Boustan, Will Dobbie, Hanming Fang, Joshua Goodman, Caroline Hoxby, Jennifer Jennings, Adam Kapor, Andrew Langan, David Lee, Steven Levitt, Michael Lovenheim, Alexandre Mas, Steve Mello, Eduardo Morales, Christopher Neilson, Cecilia Rouse, Kevin Stange, Sarah Turner, Christopher Walters, Zhihong Yu, participants at the Northeastern Economics of Education Workshop, E-conomics of Education seminar, APPAM, ASSA, AEFP, and Princeton University for helpful comments. Special thanks to the Institute of International Education for data sharing. The Princeton Industrial Relations Section and Education Research Section provided generous financial support.

†IZA - Institute of Labor Economics; mingyuc@alumni.princeton.edu.

‡University of Toronto; yanzun.yang@mail.utoronto.ca.

1 Introduction

Education is one of the most vital comparative advantages in trade for the US. In 2017-18, over one million international students studied in the US, contributing $45.3 billion.[1] Education accounted for about 14 percent of the US services trade surplus in 2018. Whereas recent immigration restrictions, the COVID-19 pandemic, and the trade war with China have cast doubt on the future of education exports (Lorin, 2019; Barros, 2020; Fischer, 2020), the impact of such service trade on the US remains unclear. On the one hand, tuition revenue from international students is crucial to many US public universities in order to cushion a loss in state funding (Shih, 2017; Bound et al., 2019; 2020). However, critics argue that international students crowd out in-state students and some have advocated for caps on nonresident enrollment (Belkin, 2017).

This paper studies the impact of education exports on the US higher education sector and sheds light on objectives of public universities in the face of changing revenue sources. We study 2003–2016, when new international student inflows doubled (IIE, 2019). This staggering influx of international students is due to both demand factors, such as the rising ability to pay for US education in developing countries, and supply factors, such as increased incentives to raise tuition revenue following the Great Recession (Bound et al., 2021). The listed tuition and fees for nonresidents are 2.6 times the amounts for in-state students (see Appendix Figure A.2), and the absolute difference has increased over time and is larger among research institutions.

Using administrative data on student visas, we first document the fiscal impact of international students by estimating their financial contributions by geographic region, institution, and degree program.[2] On average, international students' tuition revenue

[1] Source: US Department of Commerce, 2016.export.gov/industry/education

[2] Through Project ADVISE (Analytics and Data Visualization for International Student and Education), we build a data visualization tool to make estimates of international students' financial contributions available to the general public (ers.princeton.edu/project-

accounts for 12 percent of the total tuition revenue (net of institutional aid) across public universities in 2016, exceeding 30 percent for some institutions. Undergraduates' revenue constitutes more than half of the international tuition revenue from degree programs.

Next, with tuition revenue from international students increasing and state funding decreasing, we test whether US public universities choose to expand in-state enrollment or raise quality by increasing per-student spending, which leads to the displacement of in-state students. Public universities historically rely heavily on state appropriations and are mandated to educate in-state students (Groen and White, 2004). Changing university revenue sources provide an opportunity to study institutional objectives.

To do so, we estimate the causal effect of international undergraduate enrollment on various public university outcomes. We focus on undergraduates, where international enrollment increased the most (Bound et al., 2021) and public institutions face clear trade-offs. We combine two national surveys of colleges to assemble a panel dataset with rich school information on enrollment by place of origin (PO) and state residency, completions, peer quality, prices, school expenditures, and state funding.[3] We use a shift-share design exploiting variation in international enrollment driven by foreign demand for US education. We measure the foreign demand based on family's ability to pay for US services, which consists of PO-specific economic growth and exchange-rate fluctuations. Our design leverages institutions' differential exposure to foreign demand shocks based on their networks with foreign countries years prior to the recent expansion of international undergraduate students. Our results are robust to tests suggested by recent developments in the shift-share literature (Jaeger et al., 2018; Adão et al., 2019; Goldsmith-Pinkham et al., 2020; Borusyak et al., 2022).

We find that the increase in international students at US public universities does not

advise-about).

[3]We avoid using "country" to report geographic units identified in the data because not all are countries.

crowd out local students. Instead, schools expand in-state enrollment and graduate more domestic students. On average, for every one additional international undergraduate enrolled, the in-state freshman enrollment increases by 1.9 and the number of domestic students who graduate in six years increases by 1.3. We show that schools provide more access to in-state students by decreasing the listed tuition and fees. Meanwhile, the increase in international students leads universities to raise total expenditures on students but keep per-student spending constant. The increase in total expenditures is mainly attributed to instructional costs.

Furthermore, given the large increase in foreign demand for US education, public universities do not recruit international students under lower admission standards for SAT scores compared with their domestic peers. In fact, we find that enrolling more international students increases overall class academic credentials in terms of all SAT math quartiles and the bottom SAT verbal quantile without changing the top quantile. This is consistent with the fact that international students enrolled in the US have higher SAT scores on average, especially in math, compared with their US peers (Chen et al., 2023).

Lastly, we find that the allocation of state appropriations can depend on institutions' ability to generate tuition revenue from international students. Enrolling more international students decreases the state appropriations received by public research universities, which attract over 70 percent of international undergraduates at public institutions. Furthermore, the state allocates more appropriations when there is an international enrollment increase at peer institutions in the same state.

Whereas a large volume of research has focused on the demand (student) side of the higher education market, this paper contributes to our limited understanding of the supply (school) side.[4] Because universities are multi-product organizations with a

[4]Some examples of the demand side with respect to the cost of and access to higher education include Bound and Turner (2002);

complicated set of goals, it is difficult to discern their priorities. We leverage revenue shocks from international students to shed light on how public universities make trade-offs between educating in-state students and school quality or prestige, measured by per-student spending. Our results provide empirical justification for the modeling choice of a university's objective function, whereas prior literature usually takes an explicit stance on ex-ante (e.g., Epple et al., 2017; Hoxby and Stange, 2020). Relatedly, studies have examined the impact of revenue shocks from state appropriation cuts on US public institutions and found declines in enrollment and college attainment (Deming and Walters, 2017; Bound and Turner, 2007). Given that public research universities increase international student enrollment in response to state funding cuts (Bound et al., 2020), our results suggest that in the absence of international students, in-state student enrollment and degree attainment would decline at such institutions.

This paper also contributes to the empirical literature on the impact of trade on the US and has important implications for policymakers when considering trade deals. Thus far, the literature has focused on the effect of manufacturing goods imports on the US labor market and generally finds employment losses in directly competing sectors (e.g., Autor et al., 2013; Acemoglu et al., 2016; Pierce and Schott, 2016; Bloom et al., 2024). In contrast, this paper examines the impact of education service exports on the US higher education market and finds benefits for US students and institutions. In 2018, education service ranked fifth for service exports and was the third-largest contributor to the services trade surplus (see Appendix Table A.1).

Last, this paper adds to the immigration literature on international students—a population that influences US education markets, high-skilled labor markets, and local economies. Jia et al. (2025) find that inflows of Chinese graduate students led US universities to create

Deming and Dynarski (2010); Sargent et al. (2011); Stange (2012); Hoxby and Turner (2013); Pallais (2015); Becker et al. (2016), and Jacob et al. (2018).

new master's programs, increased the enrollment of other international and American master's students, particularly in STEM, and supported job creation in surrounding college towns. The papers most closely related to ours are Shih (2017) and Zhu (2025). Shih (2017) finds that international graduate students cross-subsidized domestic graduate students in 1995-2005, which is broadly consistent with the cross-subsidization result at the undergraduate level in this paper.[5]. Using a restrictive UK immigration policy change as an instrument for international enrollment in US universities, Zhu (2025) finds that international enrollment increases domestic postsecondary degree completion and documents positive cross-degree-level spillovers from international master's enrollment to domestic bachelor's degree completion.

Our paper differs from these studies in important ways. Shih (2017) is limited by the data to considering only domestic enrollment stock as the outcome and cannot distinguish university-funded doctoral students from self-paying master's students. Both Shih (2017) and Zhu (2025) exploit variation in international graduate enrollment, whereas we study undergraduates during a period of large-scale expansion in international enrollment that was driven by undergraduates. Our paper exploits rich data to examine the impact of international student inflows on various institutional outcomes, such as enrollment inflows by state residency, degree attainment, and SAT scores. Our setting and data allow us to test how public universities make trade-offs between in-state enrollment and other university interests during a period of large declines in state appropriations.

The rest of the paper proceeds as follows. Section 2 describes the data and context. Section 3 presents the conceptual framework and empirical strategy, and Section 4 reports the main results. Section 5 presents discussion and extensions. Section 6 concludes.

[5]A contemporaneous study to our paper (Shen, 2017) uses time dummies relative to 2005 as instruments and finds a negative but statistically insignificant impact of international undergraduates on domestic enrollment at public universities. These instruments are problematic because they pick up supply-side drivers of international students (Bound et al., 2020) and violate the exclusion restriction. The lack of enrollment data by state residency also makes the dependent variable harder to interpret.

2 Background and Data

2.1 Data

To estimate the financial contributions of international students, we use the universe of F-1 visa SEVIS records between 2002 and 2017 obtained from US Immigration and Customs Enforcement (ICE) via several Freedom of Information Act requests. The data contain student-level information on PO, dates of study, program of study, cost of attendance, and funding amount and source. We match this dataset with the Department of Education's Integrated Postsecondary Education Data System (IPEDS) using school name and address to obtain additional information on institutions.

We combine two national surveys of US colleges for our main causal analysis. First, information on listed tuition, expenditures, state appropriations, SAT scores, degree completion and enrollment of first-time degree-seeking undergraduates are mainly from IPEDS; institutions that receive federal financial aid via Title IV programs are required to fill out IPEDS' annual surveys. Our enrollment data are from the Fall Enrollment Survey, and an international student is defined as "any 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." We use data for the period between the 2003-2004 and 2016-17 academic years. All monetary variables are adjusted for inflation using the Higher Education Price Index. Second, following Bound et al. (2020), we use the Annual Survey of Colleges (ASC) to supplement missing data on enrollment by state residency and SAT scores. The missing data in IPEDS are due to high non-response rates on SAT scores in early years and the fact that schools are only required to report enrollment by state residency every 2 years. Our results are qualitatively the same when not using or only using data from ASC.

The 2002 ICE data are used for the baseline "share" component of the shift-share IV.

As a robustness check reported in the Appendix, we additionally use schools' historical enrollment stock by PO from the restricted-access part of the 1997 Open Doors survey (OD) to form an alternative share measure.[6] Information on GDP per capita and exchange rates for the "shift" part are from the Penn World Table 9.1.

Unless otherwise stated, the analysis in this paper focuses on four-year, Title-IV, degree-granting, public institutions in the US. We exclude schools that switched from private to public during our sample period, military schools, schools identified as primarily granting associate degrees, exclusively graduate programs, medical centers, law schools, or tribal colleges by the Carnegie Classification. Schools are required to be active throughout 2003-04 to 2016-17 and present in the 1997 OD. This results in 412 public institutions with 179 research universities. Research institutions are classified as median, high, or very high research activity by Carnegie.

Appendix Table A.2 presents the mean of key variables in selected years by institutional type. Freshman enrollment of all resident types and expenditures on instruction increased over the sample period. Whereas state appropriations decreased, the increased listed tuition for all students suggests that the increase in student expenditure came at the cost of increased tuition revenue. Furthermore, research institutions are much larger than non-research institutions, attract more international and out-of-state students, and fall into higher SAT percentiles. While research institutions spend close to 75 percent more per student than non-research institutions, they also receive more per-student state funding and charge out-of-state students much higher tuition. However, the in-state tuition difference between research and non-research institutions is much smaller.

[6]The Open Doors survey is administered annually by the Institute of International Education and focuses on international students.

2.2 Trends in education exports

Driven by middle-income regions, trade in education service (measured by the number of students studied abroad) underwent a staggering increase of 160 percent in the last two decades. In 2016, about 5 million students pursued higher education in places other than their PO (Appendix Figure A.3). A distinctive feature of trade in education is that it entails the sharing of cultural and political values and transfers of skills and labor, in addition to monetary transfers.

The US has a comparative advantage in education service over any other country in the world. It is the most popular destination country for international students seeking higher education, hosting 24 percent of all students studying abroad in 2016, followed by the UK (11 percent) and China (10 percent).[7] For 2016-17, the size of the international student body is similar to the size of degree-granting for-profit institutions, or four times the size of the University of California system. Using administrative data on F-1 visas, we estimate conservatively that international students in US higher education spent over $38 billion on tuition, fees, and living expenses after netting out financial support from US institutions, up 150 percent from 2003-04.[8] Among public universities, Appendix Figure A.4 shows that the share of tuition revenue from international students of total tuition revenue increased from 5 percent on average in 2003 to 12 percent in 2016, and by more than 30 percent for some institutions (e.g., University of Illinois at Urbana-Champaign).

International undergraduates account for more than half of all international students in the US, with an increase of 77 percent between 2003-04 and 2016-17 (43 percent for graduate students). Panel (a) of Appendix Figure A.1 shows that students from China contributed to the majority of the increase in international students, though other developing countries,

[7] Source: Project Atlas, www.iie.org/Research-and-Insights/Project-Atlas.

[8] This estimate is conservative since it does not include other student visa types such as J-1 and M visas. Living expenses exclude spending beyond regular on-campus needs such as traveling within the US.

such as South Korea, Saudi Arabia, and India, also contributed to the growth. Chinese undergraduates alone spent over $7.4 billion on net tuition and expenses in 2016-17.

The expansion of international students is unequal across institutions. As panel (b) of Appendix Figure A.1 shows, while the inflow of international undergraduates at public four-year universities started to expand in 2004-05, the subsequent expansion was concentrated in research institutions. Tuition and fees paid by international undergraduates to public four-year institutions increased 289 percent to over $6.2 billion in 2016-17, or $9.5 billion when living expenses are included. Most tuition revenue went to research universities.

2.3 Factors in international student mobility

Recent literature finds that both the demand- and supply- side factors of the US higher education market for international students are important in explaining the recent expansion of US education exports. On the demand side, in addition to an increase in the need for high-quality higher education from developing countries that is unmatched by local supply, rapid economic growth has rendered US higher education more affordable, as documented by Bound et al. (2021). Taking China as an example, between 2003 and 2016, real GDP per capita increased 200 percent. Furthermore, a regime switch to a flexible exchange rate in 2005 caused Chinese currency to appreciate by 19 percent against the USD during the same period.

Studies have demonstrated the importance of the ability to pay for US goods and services in explaining US education exports. Khanna et al. (2025) argue that a major driver of income growth in China is its accession to the World Trade Organization in 2001; they find that trade-liberalization-driven wealth can explain a quarter of Chinese enrollment in the following decade. They also show that trade liberalization first had an impact on Chinese students' inflow to the US in 2005-06, since it takes time for income

gains and college decisions to materialize. In addition, Chen et al. (2023) analyze data on over 100 PO between 2004 and 2015 and show that a PO's real GDP per capita is positively correlated with its number of SAT takers and enrollment in the US.

US immigration policies can also influence the demand side by changing international students' expected return of investing in US college applications and access to the US labor market after graduation. Increase in the perceived chance of obtaining an F-1 student visa, the chance of winning an H-1b work visa lottery, and the time allowed to work under the Optional Practical Training program all increase international students' applications and enrollment in the US (Kato and Sparber, 2013; Shih, 2016; Chen et al., 2023; Amuedo-Dorantes et al., 2023).

On the supply side, public universities in the US have had an increasing financial incentive to recruit international students. On the one hand, international undergraduates typically receive little institutional aid and pay out-of-state tuition that is 2.6 times higher than the listed in-state price (Appendix Figure A.2). Only 3 percent of all funding for tuition and living expenses comes from hosting US institutions for Chinese students seeking bachelor's degrees (Chen, 2024). Moreover, international students can often pay more than domestic out-of-state students. At least 45 states have some form of tuition reciprocity agreement that largely reduces tuition for students from surrounding states.[9] Lastly, according to the Annual Survey of Colleges, in 2017, 21 public universities charged foreign students an average additional tuition of $3,120 on top of the listed out-of-state price, and 70 public universities charged an average additional fee of $1,610.

On the other hand, while public universities historically depend on state appropriations to operate, they have had to rely more heavily on tuition revenue following each of the last three recessions. For example, the share of tuition revenue in total revenue increased permanently from 36 percent before the Great Recession to more than 47 percent

[9]Source: www.instateangels.com/tuition-reciprocity-agreements-explained

after 2012 (SHEEO, 2019). In this vein, Bound et al. (2020) find that reductions in state appropriations led to an increase in international student enrollment at public research universities.

3 Conceptual framework and empirical strategy

3.1 Objectives of public universities

Although the interests of public universities are diverse and heterogeneous, we focus on two objectives that are common to most institutions and testable with our research design. In our conceptual framework, a public university optimizes over a combination of in-state enrollment and school quality, subject to capacity and budget constraint. School quality is measured by per-student spending for now and is later extended to include the academic ability of the students in Section 5.1. The budget constraint consists of tuition revenue and state appropriation, in which state funding is determined by state legislatures whose goal is to maximize in-state enrollment in the entire state. Since a state's total funding for higher education is usually fixed, a school's state appropriation depends on its alternative source of revenue and its peer institutions' budget constraints.

An increase in international student enrollment at public universities brings additional tuition revenue and affects the two objectives under our conceptual framework. If public universities are strictly constrained in physical space, an increase in international students will displace domestic students on campus mechanically. If there is room for enrollment expansion, universities can either use the new revenue to expand seats for in-state students or increase per-student spending to improve school quality. They can also choose a mix of these two options. Hence, examining the impact of the increase in international students provides an opportunity to test which objective universities decide to optimize.

3.2 Shift-share design

To estimate the causal impact of international student enrollment on institutional outcomes, we employ the following model specification:

$$\Delta Y_{jt} = \beta \Delta E^{f}_{jt} + \Delta W_{jt}\alpha + \lambda_t + \epsilon_{jt} \tag{1}$$

where Y_{jt} is school j's outcome in the academic year t, such as in-state freshman enrollment in the fall and expenditures on students. The independent variable of interest, E^{f}_{jt}, is international freshman enrollment in the fall. W_{jt} is a vector of state-level time-varying controls and λ_t are year fixed effects. Δ represents that we take the first difference instead of using levels, which controls for any school-specific time-invariant characteristics. Year fixed effects control for aggregate trends such as overall demand for college education and immigration policies. Among W_{jt}, we control for state-level college-age populations (age-18 population) and labor market conditions (unemployment rate), since they are drivers of college enrollment (Bound and Turner, 2007). Institution-year observations are weighted by the undergraduate enrollment at baseline (2003). Standard errors are clustered at the institutional level.

Estimating equation (1) with an ordinary least squares (OLS) regression may not capture the causal impact of international enrollment for several reasons. First, increases in in-state enrollment reduce available seats and induce a reverse causality on international enrollment, which would bias OLS estimates downward. Second, there may be time-varying unobserved institutional characteristics that affect in-state enrollment and international enrollment. For instance, a change in the school's recruiting strategy or investment in a school amenity can attract students of all residencies.

To address these potential identification challenges, we construct a shift-share instrumental variable (SSIV), Z_{jt}, to measure institutions' exposure to foreign demand shocks

for US education. Specifically, we interact a measure of families' ability to pay for US colleges in a PO with institutions' historical network with students from that PO:

$$\Delta Z_{jt} = \sum_{c} \frac{E^{s}_{cjt=2002}}{E^{s}_{jt=2002}} \Delta M_{ct} \tag{2}$$

where $E^{s}_{cjt=2002}$ is the undergraduate enrollment stock of international students from PO c at school j in 2002, and $E^{s}_{jt=2002}$ is the school's total undergraduate enrollment stock, including both domestic and international students, in 2002. M_{ct} is a measure of families' ability to pay for US education from c in the period before academic year t, reflecting the time lag between application and enrollment. In practice, we use real GDP per capita in USD (PPP adjusted), which contains variation from real GDP per capita and exchange rates adjusted for the cost of living. The summation is over the top 30 PO with the highest enrollment stock in 2002, covering over 80 percent of total international enrollment in the US.

Our SSIV design requires two key assumptions for causal inference. First, the instrument Z_{jt} must have predictive power for international enrollment E^{f}_{jt}, conditional on the controls. In our SSIV, institutional exposure to foreign demand shock from a particular PO depends on the PO's enrollment share in the initial year (2002). Like the formation of immigration enclaves, prior graduates are an essential channel for establishing an international reputation and through which prospective students can obtain information. There is, in fact, a strong positive correlation between E^{f}_{jt} and Z_{jt} (see Appendix Figure A.5): Institutions with larger exposure to foreign demand shock for US education enroll more international students.

Second, initial shares of international students in 2002 must be exogenous to *changes* in other determinants of the outcome variable, conditional on observables (Goldsmith-Pinkham et al., 2020). To mitigate this concern, we test whether initial shares correlate

with pre-trends in in-state enrollment, per-student spending, and other determinants of the outcomes (population at age 18, unemployment rate, and state appropriations). Appendix Figure A.6 shows no clear correlation between initial shares for PO with the highest Rotemberg weights and changes in outcomes between 1992 and 2003. Appendix Table A.3 provides formal statistical tests and includes determinants of outcomes.

Our SSIV compares changes in outcomes between institutions with high and low exposure to foreign demand shocks. The absence of pre-trends suggests that the estimated effects are unlikely to reflect differential trends across institutions. Note that despite the shocks' being viewed as weights in Goldsmith-Pinkham et al. (2020) and not needing be exogenous, using shocks for foreign demand isolates our SSIV from time-varying supply-side factors.[10]

4 Results

4.1 The impact of education exports on university objectives

This section presents empirical results for the causal impact of the increase in international students on the two objectives of public universities laid out in Section 3.1. Table 1 reports OLS and 2SLS estimates of equation (1) for the impact on domestic enrollment by state residency. The first-stage estimates in columns 2-3 suggest that the SSIV is positively correlated with international student inflow. This supports our hypothesis that rising ability to pay for US education increases education exports.

Column 1 shows that the OLS estimate for the impact of education exports on in-state enrollment is small and statistically insignificant, while column 2 shows that the 2SLS estimate using the SSIV is statistically significant and positive. This difference is

[10] Borusyak et al. (2022) show that we can alternatively view shares as weights and require shocks to be exogenous. However, one key assumption is to not have many correlated shocks. Since shocks are correlated overtime in our panel setting, we choose to focus on the shares view.

consistent with the downward bias induced by the reverse causality discussed in Section 3. Column 3 shows that the 2SLS estimate is robust after controlling for the statewide population at age 18 and the unemployment rate. On average, for every additional international freshman enrolled, the in-state freshman enrollment increases by 1.9 at US public universities. In contrast, columns 4-6 show a small and statistically insignificant impact of education exports on out-of-state enrollment. Lastly, column 7 shows that the enrollment increase for in-state students translates into graduates: Every additional international student leads to an increase of 1.3 domestic college graduates in 6 years.

Panel A in Table 2 presents 2SLS estimates for the impact of education exports on various measures of student spending (in logs).[11] Columns 1-2 suggest that while an increase in international student enrollment leads to an increase in total expenditures on students, the effect on per-student spending is very small and not statistically significant. Columns 3-5 break down student expenditures by type and show that the increase in total spending is mainly attributed to instruction. On average, for every 10 additional international students, schools increase instructional spending by 0.006 log points. The increase in instructional spending is consistent with an increase in new faculty hires. Column 6 shows that for every 10 additional international students, schools increase new faculty hires by 1.1.

4.2 SSIV robustness checks

We perform a series of robustness checks motivated by the recent SSIV literature. As stated in Section 3, Goldsmith-Pinkham et al. (2020) show that a key identifying assumption is the exogeneity of shares to changes in unobserved determinants of the outcomes, especially for shares carrying high weights. We have shown that top-weighted POs are uncorrelated

[11]For the rest of the paper, we focus our discussions on 2SLS estimates with controls. Parallel OLS estimates are included in the Appendix.

with pre-trends of the outcomes and their observed determinants in Appendix Figure A.6 and Appendix Table A.3. In addition, the first columns of Appendix Tables A.4 and A.5 show that despite a decline in first-stage power, the 2SLS estimate is statistically indistinguishable when excluding three top-weighted POs.[12] Given the prevalence of Chinese students, column 2 also shows that our results are robust when excluding China.

Furthermore, in column 3 of both tables, we include log state appropriations as a control and find no effect on our results. This is broadly consistent with Bound et al. (2020), who find that state appropriations only affect international enrollment but not in-state and out-of-state enrollment during a similar time window. In column 4, we additionally include state fixed effects to account for state-specific time trends in the first-difference specification. The estimates remain similar, suggesting that cross-state differences are not driving our results. Moreover, following Adão et al. (2019), column 5 reports standard errors accounting for the correlation across institutions in PO shares, and our results remain the same. Column 6 presents the lagged exposure test proposed by Jaeger et al. (2018), showing that the effects on in-state freshman enrollment are unlikely to be driven by persistent pre-existing trends. Columns 7 and 8 show that our results are robust to including the top 80 POs in the share construction and to estimating unweighted regressions of equation (1).

Lastly, we examine the robustness of our results to alternative share and shock measures. In column 9 of Appendix Tables A.4 and A.5, we use the first difference in national international undergraduate inflows by PO from the Institute of International Education as an alternative shock measure. In Appendix Table A.6, we instead use schools' interna-

[12]We compute Rotemberg weights following Goldsmith-Pinkham et al. (2020) to measure the weight of each PO (see the full list in Appendix Table A.9). POs that exhibit higher real GDP per capita growth and a strong first stage correlation between initial international enrollment share and international enrollment change tend to have higher Rotemberg weights. Among the POs, China's weight ranks ninth due to its relatively low first stage correlation, despite having the highest demand shock.

tional enrollment shares in 1997 as an alternative share measure.[13] The estimates remain qualitatively unchanged under both alternative share and shock measures.

5 Discussion and extensions

5.1 What do public universities value?

Results from Section 4.1 suggest that when public universities receive additional tuition revenue from international students, they choose to expand seats for in-state students rather than increase quality by raising per-student spending. This rejects the hypothesis that international students crowd out in-state students.

Our results also suggest that schools are unlikely to be capacity constrained in physical space, but they are in monetary resources. We test further whether international students displace in-state students at more capacity-constrained schools. Columns 1-2 of Appendix Table A.7 show the impact of education exports on main outcomes of interest by whether a university requires first-year students to live on campus in the baseline year (2003). While the effects of education exports are concentrated in schools that do not require freshmen to live on campus, there is no detectable crowding-out effect at schools with a live-on-campus requirement. This result strengthens the finding that in-state enrollment is a key optimizing objective for public universities.

One dimension of school quality that has not been considered is the academic ability of students. The increased monetary incentive to recruit international students during the Great Recession may lead schools to lower admission standards for international students. Since international students also lead to higher in-state enrollment, the academic ability distribution of freshman can also be influenced by the marginal in-state student. Panel B

[13] This specification results in a smaller sample of 341 public institutions because fewer schools enrolled international undergraduate students in 1997.

of Table 2 reports the impact of education exports on SAT quartiles of the freshman class by math and verbal. The 25^{th} and 75^{th} percentiles proxy for admission thresholds and high-achiever quality.

Columns 1 and 3 show that international enrollment increase has a positive and statistically significant effect on the 75^{th} percentile of SAT math scores but has no significant effect on verbal. For every 10 additional international students enrolled, the top quartile of SAT math scores for the freshman class increases by 0.59 points. Despite a small magnitude, this result suggests that schools benefit from admitting more high-scoring students. Given that on average, international students score 105 points higher than their US peers on SAT math (Chen et al., 2023), the increase in the SAT math quartile is likely attributed to the rise in international students. An important observation is that the average share of international students in the freshman class is very small (4 percent in 2016). Hence, for the marginal international student to move the SAT percentiles of the entire freshman class, the SAT scores of the marginal student must be considerably high.

In addition, columns 2 and 4 show that education exports have significantly positive impact on the 25^{th} percentile of SAT math and verbal scores. This suggests that institutions did not systematically lower but even raise admission standards for marginal international and in-state students. A potential way schools attracted more qualified in-state students was by decreasing tuition and fees for local students. Columns 1-3 of Appendix Table A.8 show that every 10 additional international students lead to a decrease of the listed price for in-state students by 0.005 log points. In contrast, education exports have no impact on the listed price for out-of-state students or institutional aid.

Thus far, we have presented evidence to support that in-state enrollment is one of public universities' core interests. Our results do not rule out that school quality is an important objective, but is, less prioritized than in-state enrollment. Institutions with high exposure to foreign demand shocks kept per-student spending constant and did not lower

admission standards.

Whereas maximizing over in-state enrollment may be surprising when state appropriations decreased, there are several reasons why expanding seats for local residents is beneficial to public universities. First, the market for recruiting in-state students is competitive, especially with demographics shifting towards the declining college-aged population. Since local residents are the major supply of students on campus, maximizing in-state enrollment can help universities maintain a healthy enrollment level in the long run. Second, since in-state students are more likely to stay in the state after graduation (e.g., Mountjoy, 2022), they may be particularly valuable for schools seeking to build stronger local networks, attract donations, and even gain political bargaining power for higher education funding. For example, Chatterji et al. (2018) find that state legislatures with more in-state public college alumni spend more on education.

5.2 Treatment effect heterogeneity

Panel (b) of Appendix Figure A.1 shows that the expansion of education exports is concentrated in research institutions, which are typically more attractive to international students. Columns 3-4 of Appendix Table A.7 show that the impact of education exports is more pronounced at public research universities. Furthermore, columns 5-6 show that the effects are larger at institutions with a higher profit margin for international students than in-state students. The profit margin is measured by the ratio of net tuition and fees for international students to that for in-state students. Data for institutional aid is from F-1 visa administrative data and IPEDS for domestic students.

5.3 The impact of education exports on state appropriations allocation

State appropriation allocation is complex. The funding proposal is often developed by a state education board.[14] Given the limited amount of state budget for higher education funding, institutions with higher ability to generate tuition revenue from international students may receive fewer state funding appropriations.

We examine the effect of education exports on state funding received in Panel A of Table 3. Column 1 shows that an increase in international student enrollment leads to a weak decrease in state appropriations. Columns 2-3 break the sample into research and non-research institutions. Public research universities enroll over 70 percent of international undergraduates at public institutions and hence have a higher ability to generate tuition revenue from education exports. Columns 2-3 show that the effect is pronounced at research institutions. For every 10 additional international students enrolled, the state funding received by research institutions reduces by 0.007 log point. The effect is insignificant for non-research institutions, where the instrument is weak.

In Panel B, we examine whether the allocation of state appropriations within a state can depend on peer institutions' ability to attract international students. Columns 2-3 show that for both research and non-research universities, every 10 additional international students enrolled at peer institutions in the same state is associated with a 0.001 log point increase in state appropriations. These results suggest that education exports also have an impact on the allocation of state appropriations across institutions.

6 Conclusion

This paper leverages the impact of education exports on the US higher education market to better understand public universities' objectives and how schools respond to financial

[14] See Deming and Walters (2017) and Chatterji et al. (2018) for more details on the state funding determination process.

incentives. Without changing school quality, maximizing in-state enrollment subject to budget and capacity constraints is a core interest of public universities.

Contrary to criticism that international students crowd out domestic students, we find that the public sector of the US higher education market benefited greatly from international students' increase. Universities with larger increases in international students expanded in-state enrollment while maintaining school quality. Khanna et al. (2025) demonstrate that the trade deficit in goods cycles back as a surplus in US exports of education services, and this paper shows that exports in education service have a large positive impact on the US higher education market.

Note that international undergraduates have value beyond what is captured in this paper. For example, college presidents have advocated for the importance of international students by arguing that global diversity is valuable for college campuses and US students (Wong, 2018). They are also more likely to be in STEM majors and hence contribute to the STEM workforce; however, Anelli et al. (2023) find that they can shift domestic students to non-STEM majors with higher expected income.

A policy implication of this paper is that keeping foreign demand for US education high is important for US students and universities, especially given the recent revenue shortfalls due to the COVID-19 pandemic. However, the task is difficult due to recent events such as the trade war and immigration restrictions. For example, the recent political tension between the US and China may have driven some Chinese students to the UK (Bennett et al., 2019). Furthermore, China has increased its investment in providing high-quality education, and Chinese universities have increasingly been included in to top university rankings (Bound et al., 2021). One way to increase foreign demand is by relaxing immigration policies. Studies show that less restrictive student and work visas increase international student inflow to the US, especially for those with high SAT scores (Kato and Sparber, 2013; Chen et al., 2023).

References

1. Acemoglu, Daron, David Autor, David Dorn, Gordon H Hanson, and Brendan Price (2016). "Import Competition and the Great US Employment Sag of the 2000s." *Journal of Labor Economics* 34.S1, pp. 141–198.

2. Adão, Rodrigo, Michal Kolesár, and Eduardo Morales (2019). "Shift-Share Designs: Theory and Inference." *Quarterly Journal of Economics* 134.4, pp. 1949–2010.

3. Amuedo-Dorantes, Catalina, Kevin Shih, and Huanan Xu (2023). "The implications of optional practical training reforms on international student enrollments and quality." *Economic Inquiry* 61.2, pp. 253–281.

4. Anelli, Massimo, Kevin Shih, and Kevin Williams (2023). "Foreign students in college and the supply of STEM graduates." *Journal of Labor Economics* 41.2, pp. 511–563.

5. Autor, David H., David Dorn, and Gordon H Hanson (2013). "The China Syndrome: Local Labor Market Effects of Import Competition in the United States." *American Economic Review* 103.6, pp. 2121–68.

6. Barros, Aline (2020). "Foreign Students Anxious over Immigration Order." *Voice of America*.

7. Becker, Charles M, Cecilia Elena Rouse, and Mingyu Chen (2016). "Can a Summer Make a Difference? The Impact of the American Economic Association Summer Program on Minority Student Outcomes." *Economics of Education Review* 53, pp. 46–71.

8. Belkin, Douglas (2017). "University of California Proposes 20% Cap on Nonresident Students." *Wall Street Journal*.

9. Bennett, Rosemary, Boer Deng, and Didi Tang (2019). "Trump's Trade War Sends Chinese Students to British Universities." *The Times*.

10. Bloom, Nicholas, Kyle Handley, André Kurmann, and Philip A Luck (2024). "The China Shock Revisited: Job Reallocation and Industry Switching in U.S. Labor Markets." *NBER Working Paper* (No. 33098.

11. Borusyak, Kirill, Peter Hull, and Xavier Jaravel (2022). "Quasi-Experimental Shift-Share Research Designs." *Review of Economic Studies* 89.1, pp. 181–213.

12. Bound, John, Breno Braga, Gaurav Khanna, and Sarah Turner (2019). "Public Universities: The Supply Side of Building a Skilled Workforce." *RSF: The Russell Sage Foundation Journal of the Social Sciences* 5.5, pp. 43–66.

13. Bound, John, Breno Braga, Gaurav Khanna, and Sarah Turner (2020). "A Passage to America: University Funding and International Students." *American Economic Journal: Economic Policy* 12.1, pp. 97–126.

14. Bound, John, Breno Braga, Gaurav Khanna, and Sarah Turner (2021). "The globalization of postsecondary education: The role of international students in the US higher education system." *Journal of Economic Perspectives* 35.1, pp. 163–184.

15. Bound, John and Sarah Turner (2002). "Going to War and Going to College: Did World War II and the GI Bill Increase Educational Attainment for Returning Veterans?" *Journal of Labor Economics* 20.4, pp. 784–815.

16. Bound, John and Sarah Turner (2007). "Cohort Crowding: How Resources Affect Collegiate Attainment." *Journal of Public Economics* 91.5-6, pp. 877–899.

17. Chatterji, Aaron K, Joowon Kim, and Ryan C McDevitt (2018). "School Spirit: Legislator School Ties and State Funding for Higher Education." *Journal of Public Economics* 164, pp. 254–269.

18. Chen, Mingyu (2024). "The value of US college education in global labor markets: Experimental evidence from China." *Management Science* 70.2, pp. 1276–1300.

19. Chen, Mingyu, Jessica Howell, and Jonathan Smith (2023). "Best and brightest? The impact of student visa restrictiveness on who attends college in the US." *Labour Economics* 84, p. 102385.

20. Deming, David and Susan Dynarski (2010). *Into College, Out of Poverty? Policies to Increase the Postsecondary Attainment of the Poor; Targeting Investments in Children: Fighting Poverty When Resources are Limited.* University of Chicago Press.

21. Deming, David J. and Christopher R. Walters (2017). "The Impacts of Price and Spending Subsidies on U.S. Postsecondary Attainment." *NBER Working Paper* No. 23736.

22. Epple, Dennis, Richard Romano, Sinan Sarpça, and Holger Sieg (2017). "A general equilibrium analysis of state and private colleges and access to higher education in the US." *Journal of Public Economics* 155, pp. 164–178.

23. Fischer, Karin (2020). "Covid-19 Caused International Enrollments to Plummet This Fall. They Were Already Dropping." *Chronicle of Higher Education*.

24. Goldsmith-Pinkham, Paul, Isaac Sorkin, and Henry Swift (2020). "Bartik Instruments: What, When, Why and How." *American Economic Review* 110.8, pp. 2586–2624.

25. Groen, Jeffrey A and Michelle J White (2004). "In-State Versus Out-of-State Students: The Divergence of Interest Between Public Universities and State Governments." *Journal of Public Economics* 88.9-10, pp. 1793–1814.

26. Hoxby, Caroline and Sarah Turner (2013). "Expanding College Opportunities for High-Achieving, Low Income Students." *Stanford Institute for Economic Policy Research Discussion Paper* 12-014.

27. Hoxby, Caroline M and Kevin Stange (2020). *Productivity in Higher Education.* University of Chicago Press.

28. IIE (2019). *Open Doors Report on International Educational Exchange.* Institute of International Education.

29. Jacob, Brian, Brian McCall, and Kevin Stange (2018). "College as Country Club: Do Colleges Cater to Students' Preferences for Consumption?." *Journal of Labor Economics* 36.2, pp. 309–348.

30. Jaeger, David A, Joakim Ruist, and Jan Stuhler (2018). "Shift-Share Instruments and the Impact of Immigration." *NBER Working Paper* 24285.

31. Jia, Ruixue, Gaurav Khanna, Hongbin Li, and Yuli Xu (2025). "The Ripple Effects of China's College Expansion on American Universities." *NBER Working Paper* 34391.

32. Kato, Takao and Chad Sparber (2013). "Quotas and Quality: The Effect of H-1B Visa Restrictions on the Pool of Prospective Undergraduate Students from Abroad." *Review of Economics and Statistics* 95.1, pp. 109–126.

33. Khanna, Gaurav, Kevin Shih, Ariel Weinberger, Mingzhi Xu, and Miaojie Yu (2025). "Trade Liberalization and Chinese Students in US Higher Education." *The Review of Economics and Statistics* 107.5, pp. 1291–1309.

34. Lorin, Janet (2019). "Trump's Trade War With China Could Squeeze U.S. Colleges Next." *Bloomberg*.

35. Mountjoy, Jack (2022). "Community colleges and upward mobility." *American Economic Review* 112.8, pp. 2580–2630.

36. Pallais, Amanda (2015). "Small Differences That Matter: Mistakes in Applying to College." *Journal of Labor Economics* 33.2, pp. 493–520.

37. Pierce, Justin R and Peter K Schott (2016). "The Surprisingly Swift Decline of US Manufacturing Employment." *American Economic Review* 106.7, pp. 1632–62.

38. Sargent, Tanja, Mingyu Chen, Yi-Jung Wu, and Chentong Chen (2011). "Wearing New Shoes to Walk the Old Road: The Negotiation of Opposing Imperatives in High School New Curriculum Classes in China." Vol. 15. Emerald Group Publishing Limited, pp. 79–98.

39. SHEEO (2019). *State Higher Education Finance: FY 2018*. State Higher Education Executive Officers Association.

40. Shen, Ying (2017). "The Impacts of the Influx of Foreign Undergraduate Students on U.S. Higher Education." *Mimeo*.

41. Shih, Kevin (2016). "Labor Market Openness, H-1B Visa Policy, and the Scale of International Student Enrollment in the United States." *Economic Inquiry* 54.1, pp. 121–138.

42. Shih, Kevin (2017). "Do International Students Crowd-Out or Cross-Subsidize Americans in Higher Education?" *Journal of Public Economics* 156, pp. 170–184.

43. Stange, Kevin M (2012). "An Empirical Investigation of the Option Value of College Enrollment." *American Economic Journal: Applied Economics* 4.1, pp. 49–84.

44. Wong, Alia (2018). "Should America's Universities Stop Taking So Many International Students?" *Atlantic*.

45. Zhu, Julia (2025). "Comparative Immigration Policies and the Resource Effects of International Students in U.S. Higher Education." *Center for Health Economics and Policy Studies Working Paper* 20251202.

Figures and tables

Table 1: The impact of education exports on domestic enrollment

	In-state			Out-of-state			Domestic graduates in 6 years
	OLS (1)	2SLS (2)	2SLS (3)	OLS (4)	2SLS (5)	2SLS (6)	2SLS (7)
New intl. student enrollment	−0.026	1.801**	1.896**	0.030	0.421	0.395	1.251**
	(0.144)	(0.909)	(0.912)	(0.083)	(0.332)	(0.331)	(0.514)
First-stage estimates							
SSIV		0.571***	0.568***		0.571***	0.568***	0.546***
		(0.151)	(0.152)		(0.151)	(0.152)	(0.160)
1^{st}-stage F-stat		54.17	53.60		54.17	53.60	60.20
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	Yes	No	No	Yes	Yes
Observations	5,013	5,013	5,013	5,013	5,013	5,013	4,072
No. of schools	412	412	412	412	412	412	412

Notes: Dependent variables are institutions' yearly change in the number of degree-seeking first-time in-state and out-of-state undergraduates entered in the fall semester. The independent variable of interest is the yearly change in the number of degree-seeking first-time international undergraduates entered in the fall. The SSIV, defined by equation (2), reflects an institution's exposure to yearly change in foreign purchasing power of US colleges based on historical networks. Controls include lagged population at age 18 and unemployment at the state-year level. Data include four-year, Title-IV, degree-granting, public institutions in 2003/04-2016/17 academic years. Regressions are weighted by total undergraduate full-time enrollment in 2003. See Section 2.1 for more details on data. Standard errors, clustered at school level, are in parentheses. *** = significant at 1 percent level, ** = significant at 5 percent level, * = significant at 10 percent level.

Table 2: 2SLS estimates for the impact of education exports

	A. Impact on student spending					
	Log expenditures on students					
	Per pupil (1)	Total (2)	Instruction (3)	Academic support (4)	Student services (5)	No. of new faculty hires (6)
New intl. student enrollment (×10)	0.001 (0.002)	0.005** (0.002)	0.006** (0.003)	0.002 (0.004)	0.001 (0.004)	1.141*** (0.426)
1st-stage F-stat	55.90	55.90	55.90	55.90	55.90	55.47
Observations	4,858	4,858	4,858	4,858	4,858	4,529
No. of schools	411	411	411	411	411	405
	B. Impact on freshman SAT scores					
	SAT Math		SAT Verbal			
	75th pctl (1)	25th pctl (2)	75th pctl (3)	25th pctl (4)		
New intl. student enrollment (×10)	0.593** (0.264)	0.572** (0.254)	0.338 (0.247)	0.600** (0.289)		
1st-stage F-stat	51.89	51.89	51.89	51.89		
Observations	3,410	3,410	3,410	3,410		
No. of schools	366	366	366	366		
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variables in panel A are institutions' yearly change in total expenditures on students (broken down by instruction, academic support, and student services), per pupil total expenditures, and the number of new tenure-track faculty hires. Dependent variables in panel B are SAT quartiles of the freshman class in the fall by math and verbal. All monetary dependent variables are in logs and are adjusted for inflation using the Higher Education Price Index. The independent variable of interest is the yearly change in the number of degree-seeking first-time international undergraduates entered in the fall. The SSIV, defined by equation (2), reflects an institution's exposure to yearly change in foreign purchasing power of US colleges based on historical networks. Controls include lagged population at age 18 and unemployment at the state-year level. The Cragg-Donald F-statistic on the SSIV in the first-stage is reported. Data include four-year, Title-IV, degree-granting, public institutions in 2003/04-2016/17. Regressions are weighted by total undergraduate full-time enrollment in 2003. See Section 2.1 for more details on data. Standard errors, clustered at school level, are in parentheses. *** = significant at 1 percent level, ** = significant at 5 percent level, * = significant at 10 percent level.

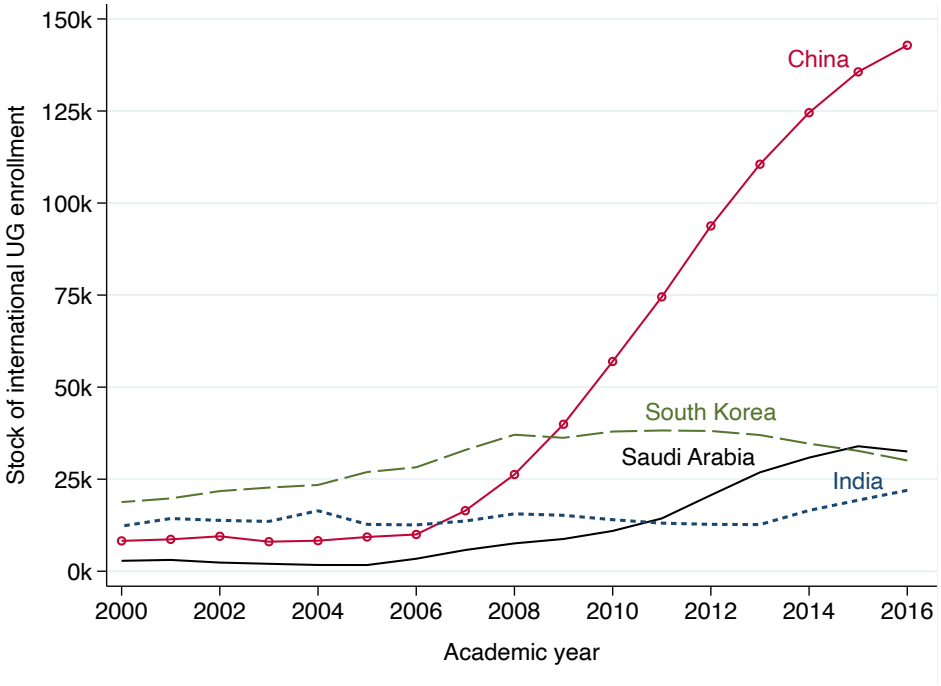
Table 3: The impact of education exports on state appropriations allocation

	Institutional type		
	All	Research	Non-research
	(1)	(2)	(3)
Panel A: 2SLS estimates			
New intl. student	−0.005*	−0.007**	0.011
enrollment (×10)	(0.003)	(0.003)	(0.025)
1st-stage F-stat	48.72	24.79	4.63
Controls	Yes	Yes	Yes
Panel B: OLS estimates			
New intl. student enrollment (×10)		0.001***	0.001***
at peer institutions in the same state		(0.000)	(0.000)
Year FE	Yes	Yes	Yes
Observations	4,892	2,117	2,775
No. of schools	412	179	234

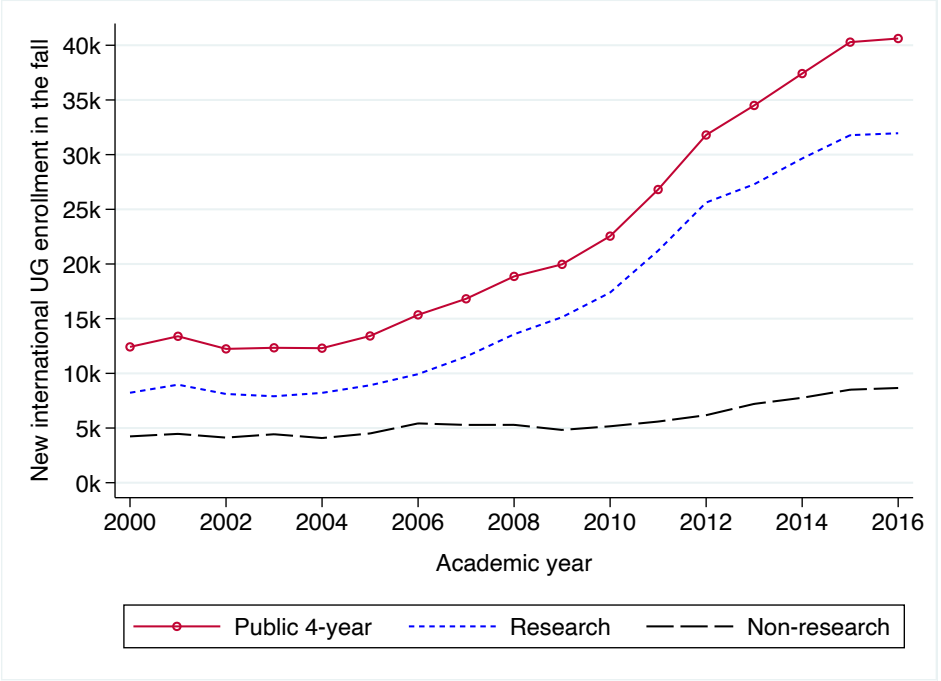
Notes: The dependent variable is state appropriations received by an institution. All monetary dependent variables are in logs and adjusted for inflation using the Higher Education Price Index. For Panel A, the independent variable of interest is the yearly change in the number of degree-seeking first-time international undergraduates entered in the fall. The SSIV, defined by equation (2), reflects an institution's exposure to yearly change in foreign purchasing power of US colleges based on historical networks. The Cragg-Donald F-statistic on the SSIV in the first-stage is reported. For Panel B, the independent variable of interest is the yearly change in new international undergraduates at peer institutions in the same state. Research institutions are classified based on Carnegie 2015 definitions of high or very high research activity. Controls include lagged population at age 18 and unemployment at the state-year level. Data include four-year, Title-IV, degree-granting, public institutions in 2003/04-2016/17. Regressions are weighted by total undergraduate full-time enrollment in 2003. See Section 2.1 for more details on data. Standard errors, clustered at school level, are in parentheses. *** = significant at 1 percent level, ** = significant at 5 percent level, * = significant at 10 percent level.

A Appendix figures and tables

Figure A.1: International undergraduate enrollment in the US



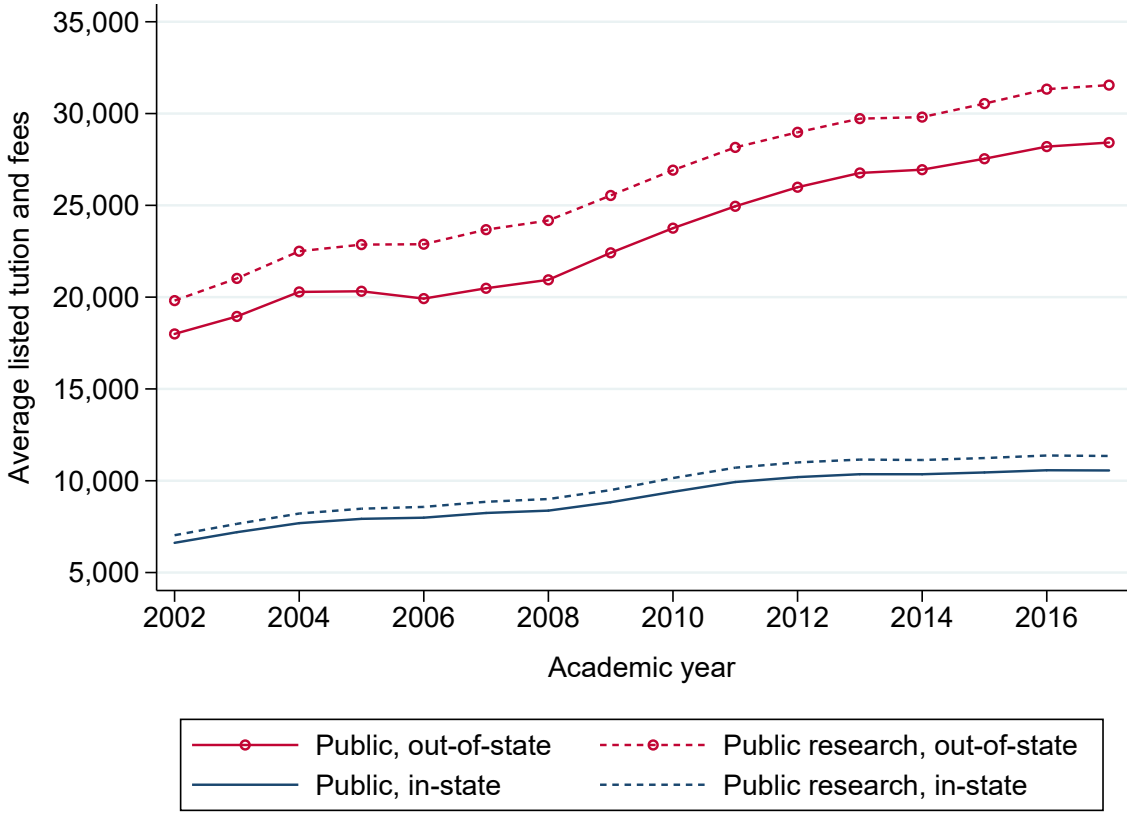
(a) By top place of origin, enrollment stock



(b) By public four-year university type, new enrollment in fall

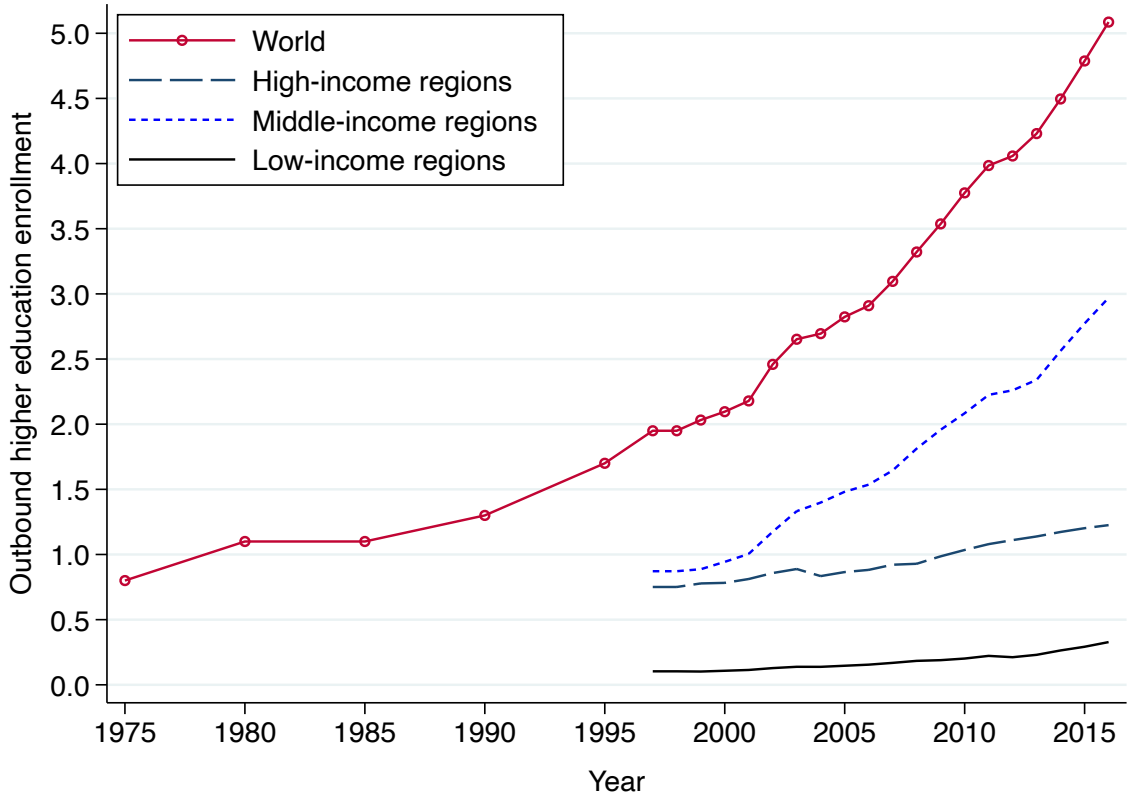
Note: Data for (a) include all undergraduate degree-granting institutions and are from the Institute of International Education, and data for (b) include public four-year universities only and are from IPEDS, both for the 2000/01 to 2016/17 academic years.

Figure A.2: Listed undergraduate tuition and fees at public four-year institutions



Note: The figure shows the average published tuition and fees weighted by FTE reported in IPEDS at four-year, Title-IV, degree-granting, non-online, and public four-year US institutions between 2002/03 and 2017/18 academic years. Prices are adjusted for inflation using the Higher Education Price Index in 2019 USD. Research institutions are classified based on Carnegie's 2015 definitions of high or very high research activity.

Figure A.3: Worldwide outbound tertiary education enrollment (millions)



Data Source: The United Nations Educational, Scientific and Cultural Organization, and the Institute of International Education's Project Atlas for outbound enrollment data prior to 1997.

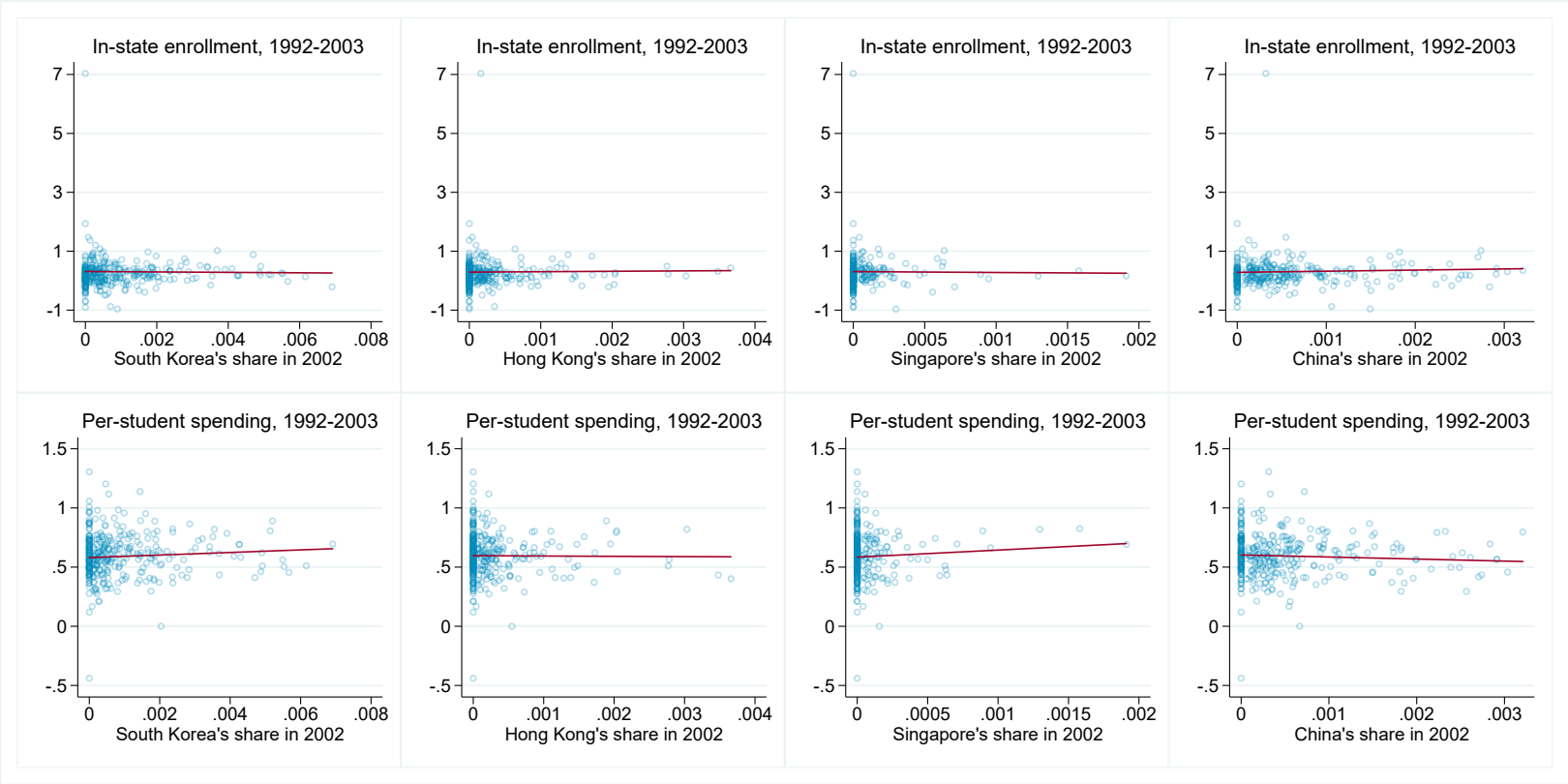
Figure A.4: Share of net tuition revenue from international students in total tuition revenue

Note: Data on international students' tuition revenue net of institutional aid are from administrative data on F-1 visas obtained from ICE. Data on total tuition revenue are from IPEDS. The box plot shows percentiles of the revenue share distribution across public four-year universities weighted by FTE.

Figure A.5: Graphic presentation of the first-stage regression

Note: The figure shows a binned scatter plot of data on the change in international freshman enrollment, change in foreign demand shock IV, and the fitted line using the estimate from the first-stage regression in column 3 of Table 1.

Figure A.6: Correlation between initial shares of top PO and pre-trends in outcomes



Note: Changes in outcomes are measured in log change.

Table A.1: US trade in services by type in 2018

Service category	Exports (millions $)	Share in surplus	Rank in surplus %
Personal travel–Other	127,054	0.040	12
Professional & Mngmt consulting svc	86,828	0.151	2
Financial Mngmt, advisory, & custody svc	53,335	0.157	1
Use of IP–Industrial processes	45,287	0.078	7
Personal travel–Education	44,715	0.139	3
Research & development svc	42,555	0.031	13
Air transport–Passenger	41,465	-0.002	23
Business travel	38,813	0.086	5
Use of IP–Computer software	37,643	0.105	4
Technical, trade-related, & other business svc	36,438	0.026	15
Maintenance & repair svc	30,967	0.086	6
Credit card & other credit-related svc	25,766	0.063	10
Computer svc	24,455	-0.032	26
Use of IP–Trademarks & franchise fees	23,997	0.076	8
Use of IP–Audio-visual & related products	21,749	0.021	18
Secty lending, elec funds xsfer, & other fin svc	21,425	0.067	9
Government goods & svc	21,235	-0.007	24
Insurance svc	17,465	-0.096	27
Sea transport–Port	15,610	0.049	11
Air transport–Freight	15,333	0.024	16
Secty brokerage, underwriting, & related svc	11,489	0.024	17
Air transport–Port	11,390	-0.011	25
Information svc	9,386	0.026	14
Telecommunications svc	9,355	0.014	19
Other modes of transport	5,149	0.005	21
Personal travel–Health	4,097	0.006	20
Sea transport–Freight	3,903	-0.124	28
Use of IP–Other	72	0.000	22
Total service exports		826,981	
Total surplus in trade svc		259,660	

Source: Bureau of Economic Analysis.

Table A.2: Summary statistics (mean) by public institutional type in selected years

	All			Research			Non-research		
	2005 (1)	2011 (2)	2016 (3)	2005 (4)	2011 (5)	2016 (6)	2005 (7)	2011 (8)	2016 (9)
New undergraduate enrollment									
International	29	59	88	47	111	164	14	19	29
In-state	1,600	1,714	1,765	2,407	2,547	2,666	986	1,081	1,072
Out-of-state	283	344	410	481	599	733	133	151	162
Outcome of domestic cohort in 6 years									
Graduate	1,042	1,200	.	1,743	2,003	.	505	589	.
SAT of the freshman class									
Math 75th pctl	588	585	583	614	619	620	564	556	551
Math 25th pctl	478	477	473	503	505	505	453	452	446
Verbal 75th pctl	579	571	570	601	598	602	558	546	541
Verbal 25th pctl	469	461	462	490	485	490	449	440	438
Listed tuition and fees (2019 USD)									
In-state	7,453	9,177	9,896	8,218	10,264	11,069	6,872	8,350	8,994
Out-of-state	18,889	21,465	22,770	21,903	25,455	27,581	16,596	18,430	19,074
State appropriations (2019 USD, millions)									
State funding	120	100	105	212	176	185	50	43	44
Expenditures on students (2019 USD, millions)									
Instructional	127	165	179	231	297	328	48	63	64
Academic supp.	33	46	53	62	87	102	11	15	16
Student service	19	26	30	30	41	48	11	15	16
Total	179	238	263	323	425	477	70	94	97
No. of schools		412			179			233	

Notes: Data include four-year, Title-IV, degree-granting, public institutions observed in both IPEDS and IIE data. Monetary variables are adjusted for inflation in 2019 dollars using the Higher Education Price Index. Research institutions are classified based on Carnegie 2015 definitions of medium, high, or very high research activity. See Section 2.1 for more details on data.

Table A.3: Pre-trends test

	South Korea (1)	Hong Kong (2)	Singapore (3)	China (4)
In-state	−0.731	1.423	−2.887	3.853
	(2.193)	(4.722)	(7.698)	(4.448)
Per-student spending	1.085	−0.262	6.010	−1.729
	(0.795)	(2.616)	(3.886)	(1.854)
State pop 18	0.144	1.708	1.320	1.549
	(0.623)	(1.313)	(2.724)	(1.312)
Unemployment rate	6.168	24.487	48.708	18.052
	(8.992)	(19.251)	(35.285)	(13.608)
State appropriations	−1.358*	−2.869	−3.461	−1.138
	(0.784)	(2.014)	(2.972)	(1.897)
Observations	353	353	353	353

Notes: Dependent variables are log change in in-state enrollment, per-student spending, population 18, unemployment rate and state appropriations for public institutions between 1992 and 2003. The independent variable is the initial international enrollment share of top PO in 2002, scaled up by 10. Standard errors, clustered at school level, are in parentheses. *** = significant at 1 percent level, ** = significant at 5 percent level, * = significant at 10 percent level.

Table A.4: SSIV robustness checks: In-state freshman enrollment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Exclude top 3 Rotemberg weight	1.955*								
	(1.107)								
Exclude China		2.205**							
		(1.040)							
Add state app. as a control			1.880**						
			(0.896)						
Add state FE				2.173*					
				(1.279)					
AKM SE test					1.896***				
					(0.383)				
Lagged SSIV						3.899			
						(2.530)			
						−1.570			
						(2.100)			
Include 80 PO in share							1.948*		
							(1.050)		
Not weighted								3.364***	
								(1.087)	
Use tot. intl. UG inflows by PO as shock									1.747*
									(0.942)
1st-stage F-stat	29.63	44.24	54.75	22.98	53.60	3.73	42.57	14.79	52.74
Observations	4,871	5,013	4,903	4,851	5,013	4,871	5,011	5,013	5,006
No. of schools	412	411	411	395	411	408	411	411	412

Notes: All columns include year fixed effects and controls. Clustered standard errors at school level are in parentheses. *** = p<0.01, ** = p<0.05, and * = p<0.1.

Table A.5: SSIV robustness checks: Log of per-student spending

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Exclude top 3	−0.000								
Rotemberg weight	(0.000)								
Exclude China		0.000							
		(0.000)							
Add state app.			0.000						
as a control			(0.000)						
Add state FE				0.000					
				(0.000)					
AKM SE test					0.000				
					(0.000)				
Lagged SSIV						0.001			
						(0.001)			
						−0.001			
						(0.001)			
Include 80 PO in share							−0.000		
							(0.000)		
Not weighted								0.001	
								(0.001)	
Use tot. intl. UG inflows									−0.000
by PO as shock									(0.000)
1st-stage F-stat	31.22	46.55	56.87	22.61	55.90	4.49	46.62	16.35	57.52
Observations	4,717	4,857	4,768	4,696	4,858	4,717	4,855	4,858	4,856
No. of schools	411	411	411	395	411	408	411	411	412

Notes: All columns include year fixed effects and controls. Clustered standard errors at school level are in parentheses. *** = p<0.01, ** = p<0.05, and * = p<0.1.

Table A.6: SSIV robustness checks using 1997 shares

	(1) In-state enrollment	(2) Log per-student spending	(3) SAT math 75^{th} pctl	(4) Log state appropriations
New intl. student enrollment	1.940*	−0.002	0.564*	−0.008**
	(1.065)	(0.002)	(0.305)	(0.004)
1^{st}-stage F-stat	33.10	31.55	32.13	33.01
Observations	4,319	4,148	3,010	4,153
No. of schools	341	341	310	339
Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The independent variable of interest is the yearly change in the number of degree-seeking first-time international undergraduates entering in the fall. Column (1) reports the effect on in-state undergraduate enrollment; column (2) reports the effect on log per-student spending; column (3) reports the effect on the 75th percentile of SAT math scores; and column (4) reports the effect on log state appropriations. All columns include year fixed effects and controls for lagged population at age 18 and unemployment at the state-year level. Regressions are weighted by total undergraduate full-time enrollment in 2003. Standard errors, clustered at the school level, are in parentheses. *** = p<0.01, ** = p<0.05, and * = p<0.1.

Table A.7: 2SLS estimates heterogeneity for the impact of education exports

	Live on campus		Research		Net tuition ratio	
	Yes	No	Yes	No	Above p50	Below p50
	(1)	(2)	(3)	(4)	(5)	(6)
	A. In-state undergraduate enrollment					
New intl. student	−0.807	3.397**	1.792*	10.309	1.855**	2.483
enrollment	(1.133)	(1.556)	(1.075)	(7.051)	(0.920)	(2.619)
1st-stage F-stat	18.15	24.28	22.04	3.04	50.22	8.31
Observations	1,754	3,243	2,133	2,864	2,559	2,329
No. of schools	140	272	179	234	205	198
	B. Log of per-student spending					
New intl. student	0.001	−0.001	0.001	−0.011	−0.000	0.000
enrollment (×10)	(0.004)	(0.003)	(0.003)	(0.017)	(0.002)	(0.006)
1st-stage F-stat	18.52	26.21	23.67	5.43	50.31	9.53
Observations	1,690	3,151	2,118	2,723	2,470	2,278
No. of schools	140	271	179	233	205	197
	C. SAT math 75th pctl					
New intl. student	0.640	0.581*	0.735**	−2.149	0.718**	0.449
enrollment (×10)	(0.589)	(0.329)	(0.314)	(1.607)	(0.279)	(0.638)
1st-stage F-stat	23.15	25.06	24.79	4.63	52.87	9.54
Observations	1,099	2,299	1,752	1,646	1,709	1,634
No. of schools	125	241	171	195	183	175
	D. Log of state appropriations					
New intl. student	−0.003	−0.006*	−0.007**	0.011	−0.007***	0.000
enrollment (×10)	(0.005)	(0.004)	(0.003)	(0.025)	(0.002)	(0.007)
1st-stage F-stat	23.15	25.06	24.79	4.63	52.87	9.54
Observations	1,672	3,220	2,117	2,775	2,471	2,321
No. of schools	140	272	179	234	205	198
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The net tuition ratio is the net tuition and fees for international students divided by net tuition and fees for in-state students, where net is defined as taking out institutional aid. The independent variable of interest is the yearly change in the number of degree-seeking first-time international undergraduates entered in the fall. Controls include lagged population at age 18 and unemployment at the state-year level. Data include four-year, Title-IV, degree-granting, public institutions in 2003/04-2016/17. Regressions are weighted by total undergraduate full-time enrollment in 2003. Standard errors, clustered at school level, are in parentheses. *** = significant at 1 percent level, ** = significant at 5 percent level, * = significant at 10 percent level.

Table A.8: 2SLS estimates for the impact of education exports on other outcomes

	Tuition and fees		
	In-state	Out-of-state	Institutional aid
	(1)	(2)	(3)
New intl. student enrollment (×10)	−0.005** (0.002)	−0.001 (0.002)	−0.009 (0.008)
1st-stage F-stat	50.62	50.62	55.10
Year FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	4,823	4,823	4,969
No. of schools	411	411	412

Notes: Dependent variables are listed tuition and fees for in-state students, out-of-state students, and institutional aid. All monetary dependent variables are in logs and adjusted for inflation using the Higher Education Price Index. The independent variable of interest is yearly change in the number of degree-seeking first-time international undergraduates entered in the fall. The SSIV, defined by equation (2), reflects an institution's exposure to yearly change in foreign purchasing power of US colleges based on historical networks. Controls include lagged population at age 18 and unemployment at the state-year level. The Cragg-Donald F-statistic on the SSIV in the first-stage is reported. Data include four-year, Title-IV, degree-granting, public institutions in 2003/04-2016/17. Regressions are weighted by total undergraduate full-time enrollment in 2003. See Section 2.1 for more details on data. Standard errors, clustered at school level, are in parentheses. *** = significant at 1 percent level, ** = significant at 5 percent level, * = significant at 10 percent level.

Table A.9: Rotemberg weights for top 30 PO

	Rotemberg weights	
Place of origin	In-state	Per-student spending
South Korea	0.214	0.250
Hong Kong	0.193	0.145
Singapore	0.157	0.174
Indonesia	0.149	0.121
Saudi Arabia	0.089	0.082
Taiwan	0.075	0.056
India	0.064	0.072
Malaysia	0.061	0.063
China	0.050	0.048
Trinidad & Tobago	0.015	0.030
Canada	0.012	0.015
Pakistan	0.009	0.010
Turkey	0.008	0.011
Thailand	0.006	0.006
United Kingdom	0.003	−0.001
Colombia	0.002	0.005
France	0.002	0.001
Bangladesh	0.001	0.001
Jamaica	−0.001	−0.001
Brazil	−0.002	−0.001
Nepal	−0.003	−0.002
Kenya	−0.004	−0.003
Germany	−0.004	−0.002
Romania	−0.004	−0.005
Japan	−0.006	−0.001
Nigeria	−0.008	−0.009
Mexico	−0.009	−0.018
Bulgaria	−0.014	−0.014
Russia	−0.022	−0.008
Venezuela	−0.033	−0.027

Table A.10: OLS estimates of the impact of education exports on student spending

	Log expenditures on students					
	Per pupil (1)	Total (2)	Instruction (3)	Academic support (4)	Student services (5)	No. of new faculty hires (6)
New intl. student enrollment (×10)	−0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.001 (0.001)	−0.034 (0.058)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,858	4,858	4,858	4,858	4,858	4,529
No. of schools	411	411	411	411	411	405

Notes: Dependent variables are institutions' yearly change in total expenditures on students (broken down by instruction, academic support, and student services), per-pupil total expenditures, and the number of new tenure-track faculty hires. All monetary dependent variables are in logs and adjusted for inflation using the Higher Education Price Index. The independent variable of interest is yearly change in the number of degree-seeking first-time international undergraduates entered in the fall. Controls include lagged population at age 18 and unemployment at the state-year level. Data include four-year, Title-IV, degree-granting, public institutions in 2003/04-2016/17. Regressions are weighted by total undergraduate full-time enrollment in 2003. See Section 2.1 for more details on data. Standard errors, clustered at school level, are in parentheses. *** = significant at 1 percent level, ** = significant at 5 percent level, * = significant at 10 percent level.