THE IMPACTS OF THE INFLUX OF NEW FOREIGN UNDERGRADUATE STUDENTS ON U.S. HIGHER EDUCATION

Ying Shen*
University of Notre Dame

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Abstract

Using data from the Integrated Postsecondary Education Data System (IPEDS), this paper examines the impacts of the dramatic increase in new foreign undergraduate students over the past decade on the U.S. higher education sector. Since which a school's foreign attend is a choice variable, I use exogenous factors driving the large inflow of Chinese students since 2006, in combination with variation in historical levels of foreign students as the instrument to predict enrollment patterns. Using a two-stage least square model that is identified with a difference-in-differences specification, I find a significant crowd-out effect of the enrollment of foreign undergraduate students on the enrollment of domestic undergraduate students at American higher-ranked research universities, approximately one-for-one. Constraints in the demand for students in large selective universities appear to explain the crowd-out effect. I also find that while admitting more undergraduate foreign students increases non-discounted tuition, the economic gains of enrolling foreign undergraduate students allow American universities to increase institutional grant aid.

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1 Introduction

The globalization of higher education over the last 70 years has transformed the faculty and graduate student bodies of American universities, changing how we train, fund, and inform our knowledge workforce (Borjas (2004), Borjas et al. (2015), Bound et al. (2009), Shih (2015), etc). Until recently, the undergraduate side of American education has remained relatively immune from the direct impact of globalization. In the last ten years there has been a large influx of international students at the undergraduate level, many from China. Data from the Institute of International Education (IIE) reveals that from 2005 to 2013, the number of foreign undergraduate students studying at U.S. institutions increased by more than 55 percent, rising from 240,000 to 370,000. Chinese students comprised about 77 percent of the increase in foreign undergraduate students. American undergraduate education has become a service sought after by millions of students around the world who now have the income to pursue it, and American universities are beginning to respond aggressively to this international demand. Because of the size and importance of undergraduate education for the U.S. economy in general, this third phase of the globalization of U.S. higher education has the potential to be even more transformative than those at the faculty and graduate student levels before it. A university with constraints in the demand for students may force out a number of qualified American students as more foreign undergraduate students enter the American educational system, which would have transformative impacts on U.S. labor force and long-term economy. In comparison, the enormous economic benefits from admitting foreign students might lead to a cash revolution at American institutions which may result in fundamental changes in a university's financial and enrollment system.

While existing research (Hoxby (1998), Jackson (2014)) has studied the impact of foreign born students who immigrated to the United States at a younger age and then attend college here, there has been little work on what happens when American colleges admit a larger number of their student body from overseas. The former influx is more limited in its ultimate potential to transform undergraduate education because of limitations on immigration in general that are unlikely to drastically change. The latter influx drastically increases the potential number of applicants for

American universities, exposing students already in the U.S. to new potential competitors and peers, and providing the universities themselves with potentially vast new sources of revenue. These changes could have important implications for domestic students, tuition and fees, institutional financial aid, and salaries.

In order to estimate the causal impacts of the influx of foreign students on American undergraduate students and institutions, I make use of a quasi-experiment induced by changes to visa policies and currency exchange rates in 2006 in China that led to a large increase in the number of Chinese undergraduate students enrolling in American universities. The changes in national policies are plausibly exogenous factors driving the foreign student influx because the policy changes are orthogonal to each individual university's characteristics. However, cross-time variation by itself cannot separate the causal effects from other secular trends,therefore, I further exploit a cross-university difference in the historical presence of foreign students before the supply shock. Thus, model identification in this paper relies on both cross-time and cross-sectional variations. Specifically, I first calculate the number of foreign undergraduate students at each institution before the foreign student supply shock, predicting future student inflows. I then instrument the actual number of new foreign students at each institution by allocating the foreign supply shock in proportion to their school-level presence before the shock.

My first-stage results indicate that institutions with a higher number of foreign undergraduate students before the supply shock disproportionately enrolled more new foreign undergraduate students after 2006. The instrumental variables (IV) results suggest that although the average crowd-out effect of foreign undergraduate students on domestic undergraduate students is statistically insignificant, at higher ranked universities there is a statistically significant crowd-out effect of approximately one-for-one. In other words, for every one additional foreign student enrolled in higher ranked universities, one domestic student was denied acceptance. Exploring the mechanism behind the crowd-out effect, I find that constraints in the demand for students in large selective universities appear to explain the crowd-out effect, with more demand constrained universities experiencing a more significant effect. At the same time, the influx of foreign undergraduate students has increased U.S. admission standards, measured by SAT scores. Additionally, I also investigate

the impacts of the influx of new foreign students on other outcomes of interest to examine whether the influx affects tuition and fees charged by institutions, institutional financial support for students and salaries for instructional staff. I find that although the foreign influx has little impact on institutional fees, it increases non-discounted tuition.[1] Admitting more foreign undergraduate students enables a university to increase the average amount of institutional grant aid for their accepted students.

Concerns over the consequence of the recent explosion in the number of foreign undergraduate enrollment on U.S. higher education and economy have attracted great interest. A large number of news media extensively reported potential impacts of foreign students streams on U.S. colleges, and the government has adjusted several immigration policies in response to the recent foreign student inflows, such as the changes in the STEM OPT-extension.[2,3] This study, therefore, provides informative results for recent immigration policy discussions and offers guidance for future policy-decision making. The results in this analysis suggest that the influx of new foreign undergraduate students had both positive and negative impacts on American universities and student population, generating a long-term effect on the U.S. economy. On the one hand, the increase in the number of students in the application pool heightened a university's admission standards, allowing them to select higher quality students. The increase in school revenue earned from foreign students improved schools' financial conditions, enabling them to provide more institutional grant aid for their students, which could have positive impacts on student's academic and post-graduation outcomes (Dynarski (1999), van der Klaauw et al. (2002), Field (2006), Rothstein and Rouse

[1]Non-discounted tuition includes out-of-state tuition at public universities and tuition at private universities. Both of these two types of tuition are sticker price,not net price.

[2]Please refer to two prominent articles in *New York Times* and *Wall Street Journal* that are about foreign student streams. Links:`http://www.wsj.com/articles/international-students-stream-into-u-s-colleges-1427248801`, `http://www.nytimes.com/2014/12/01/education/chinese-students-lead-foreign-surge-at-us-colleges.html?_r=0`

[3]Historically, the U.S. immigration policies tightly restricted the number of foreign students who could work in the U.S. (i.e. the H1-B cap) but placed no caps on the number of student visas. However, in March 2016, the Department of Homeland Security published a final rule extending the STEM OPT extension from 17 months to 24 months. The OPT is a period during which foreign students with F-1 status who obtain a Bachelor's or higher degree are permitted to work in the U.S. before they get H1-B visas. The regular OPT period is 12 months, in 2008, the U.S. government announce a 17-month OPT extension for students in STEM majors. The new extension, therefore, allows foreign STEM workers who graduate from U.S. colleges to have an even longer period to legally work in the U.S. before they get H1-B visas. In these days when the probability in winning H1-B lottery is low, OPT and OPT-extension play important roles for foreign students who work and stay in the U.S.

(2011),etc). On the other hand, constraints in student demand cause foreign students to crowd out domestic students at higher ranked research universities, which would have negative impacts on crowded-out students' labor market outcomes(Card (1999), Carneiro et al. (2011)). Additionally, if a large number of foreign students cannot remain in the U.S. labor market after graduating because of policy restrictions (i.e. the H1-B visa cap), the displacement of foreign students on domestic students would leave the U.S. labor market with a chronic shortage, which would harm U.S. long-term economic growth. These are tradeoffs that will be useful to take into account during the debate on immigration policy reform.

The remainder of this paper is organized as follows: Section 2 provides a brief description of the background of the foreign student supply shock induced by Chinese students after 2006. Section 3 illustrates the conceptual hypothesis. Section 4 explains the construction of the data. Section 5 outlines the empirical identification strategy. Sections 6 and 7 report the results and robustness checks. Section 8 gives a conclusion and discussion.

2 Background

2.1 A Brief History of Chinese Undergraduate Students in the U.S.

The number and characteristics of Chinese students in the United States has varied dramatically since the establishment of the People's Republic of China in 1949. Between 1949 and the late 1970s, China's pro-Soviet "leaning to one side" policy and the Cultural Revolution limited the flow of Chinese students to the United States to negligible levels.[4,5] Beginning in 1979, a large number of Chinese students entered American institutions, as China implemented the "Open Up" policy and the Chinese government encouraged students to study abroad and learn from the developed Western countries. By the late 1980s, although China had become the leading supplier of

[4]Between 1949 and the 1960s, the Chinese government was firmly committed to the Sino-Soviet alliance. In terms of higher education, the government implemented the "leaning to one side" policy, and the Soviet Union was the dominant country receiving Chinese international students.

[5]The Cultural Revolution began the spring of 1966 and lasted until October 1976. During those 10 years, the Chinese government implemented a closed-door policy, isolating itself internationally, both from the communist alliance and from Western developed countries. Therefore, the Culture Revolution shut down the opportunity for any Chinese student to study abroad. (Wang (2001))

international students to the U.S., the majority of Chinese students were concentrated in doctoral programs in the United States.[6]

However, beginning in 2006, a new pool of Chinese students began enrolling in undergraduate programs in the U.S. This was mainly due to changes in two national policies enacted in 2005: a U.S.-China agreement relaxing student visa policies, and a change in China's official exchange rate regime that has led to a long run appreciation in its currency.[7]

In 2005, the U.S. government relaxed student visa policies, causing Chinese scholars and students to enter into the U.S. more efficiently. Before this relaxation, visa policies towards Chinese students were restrictive in that they not only affected the accepted students, leaving them unable to complete their study at U.S. institutions, but also negatively affected the enthusiasm of potential foreign applicants.[8] Given that such restrictive visa policies might have adverse effects on America's position at the forefront of technological and academic innovation, in 2005, the United States and China reached an agreement on mutually relaxing visa requirements for students and scholars. Under the new visa policies, Chinese citizens applying for student visas (F-1/F-2), exchange visas (J-1/J-2) and vocational training visas (M-1/M-2) are allowed to obtain visas that are valid for twelve months and multiple entries, compared to the previous six-month and two-entry policy. More important, the new agreement significantly reduced the refusal rate of Chinese student visas. A survey conducted by American Physics Society tracking Chinese students' visa problems suggests that during 2001-2002 academic year, a Chinese citizen on average was about three times as likely to have experienced student visa problems.[9] However, the visa approval rate for Chinese students increased dramatically after 2006. Between 2002 and 2004, the approval rate for student visa (F-1) was around 55 percent; but in 2006, the issuance rate climbed up to 76 percent, and in 2009 and 2013, the issuance rate for F-1 further rose to 85 percent and 90 percent,

[6]Data are from Institute of International Education (2013) and Institute of International Education (2009).

[7]The Chinese currency began depreciating against the U.S.dollar since early 2014, but between 2005 and 2013, the Chinese currency was consistently appreciating.

[8]The high visa refusal rate negatively affects the enthusiasm of foreign applicants is because a restrictive visa application process might dissuade potential applicants from applying to American universities in general and encourage them to pursue education in other countries such as the UK or Austrailia.

[9]Specifically, a Chinese citizen was almost four times as likely to have experienced a student visa problem he or she ultimately could overcome in time, and was two and a half times as likely to have experienced a student visa problem he or she could not overcome in time for the start of the 2001-2002 academic year.

respectively. The increase in the visa approval rate, therefore, has greatly and effectively promoted the enthusiasm of Chinese applicants.

In addition to the changes in visa policies, the Chinese currency (Renminbi) has appreciated against the U.S. dollar by more than 30 percent since July 21st, 2005, when the Chinese government announced the changes in its official exchange rate regime.[10] Figure 1 plots the exchange rate of the U.S. dollar against Chinese Renminbi between 2000 and 2014. The figure shows that before 2005, the value of the Renminbi was pegged to the U.S. dollar, and the exchange rate of the U.S. dollar to the Renminbi hovered around 8.27. However, right after July 2005, the Renminbi continued appreciating, and the central parity rate of the Renminbi stood at approximately 6.2 yuan per dollar at the end of 2013. As a result of the appreciation of the Renminbi, studying in U.S. colleges became cheaper. Therefore, compared to other places such as Japan, Australia and European countries, which also traditionally receive a considerable number of international students, the United States has become more attractive to Chinese families, inducing more Chinese students to choose the U.S. as their destination.[11]

Taken together, a combination of the streamlined student visas application procedures and the appreciation of the Chinese currency against the U.S. dollar have led to a significant increase in the number of Chinese undergraduate students in American universities, post 2006. Figure 2 illustrates the number of Chinese undergraduate students in all fields studying at American institutions between 2000 and 2013. It is evident that there was a sudden and dramatic increase in the number of Chinese undergraduate students sometime around 2006. In fact, the number of admitted Chinese undergraduate students increased almost thirteen-fold in this period, rising from 8,252 to 110,550. Although the plausibly exogenous foreign supply shock induced by Chinese students provides an opportunity to investigate the effects of foreign students on institutional outcomes, my identification does not only rely on the difference in time dimension, because later

[10]The Chinese government removed the Renminbi's peg to the U.S. dollar on July 21, 2005, and switched into a managed floating exchange rate mechanism based on market supply and demand, with reference to a basket of currencies.

[11]The exchange rates of the Japanese yen (JPY), Australian dollar (AUD) and Euro (EUR) against the Renminbi do not show sharp and persistent depreciations after 2006. Exchange rate data could be retrieved from *http://www.oanda.com/lang/cns/currency/historical-rates/*.

years might be different from earlier years in various aspects. Therefore, in addition to comparing institutional outcomes in pre-shock periods with those in post-shock periods, I also exploit cross-university variation to take out other factors aside from the foreign supply shock that might affect institutional outcomes in the first and second periods.

2.2 Economic Benefits from Foreign Undergraduate Students

Admitting foreign undergraduate students could produce large economic benefits (Bound et al. (2016)). In the U.S., while most private colleges do not charge different tuition and fees based on student residency status, public colleges charge two types of tuition and fees: in-state (discounted) tuition and fees for the residents of the state where a college is located and out-of-state (non-discounted) tuition and fees for American students living in other states, as well as all foreign students. Data from the *Trends in College Pricing 2015* show that tuition and fees at an American nonprofit private university were $32,405, while in-state tuition and fees and out-of-state tuition and fees at an American public four year university were $9,410 and $23,893, respectively. Therefore, at least at public universities, tuition and fees charged to a foreign student are considerably higher than tuition and fees charged to a local domestic student.

Additionally, compared to domestic students, foreign students receive less financial aid from American institutions. The *Institution of International Education Open Doors 2015 Reports* states that 72 percent of all foreign students receive the majority of their education funds through their families and/or home country government, and among the 28 percent of foreign students who receive financial aid from U.S. institutions, most of them are graduate students with assistantships or fellowships. That is to say, foreign students enrolled at the undergraduate level are typically self-funded, with little institutional financial aid. In contrast, *IPEDS Fast Facts* suggests that more than 80 percent and 40 percent of first-time full-time American undergraduate students received institutional grant aid in 2012-2013 at private non-profit and public institutions, respectively.

In sum, because foreign undergraduate students tend to pay a higher amount of tuition and fees, especially at public schools, and have little opportunity to receive institutional grant aid, the economic revenue per capita from a foreign student is much larger than their American peers.

3 Conceptual Hypotheses

Many factors affect a college's admission decision, including the relative quality of the applicants, the possibility that foreign students pay for a higher fraction of tuition and fees, and the desire to diversify the student population. Therefore, the influx of foreign students may alter the educational opportunities available to domestic students in different ways.

The crowd-out effect may work through both direct and indirect channels. Directly, at least in the short run, the number of slots available for prospective students at a particular school is fixed due to constraints in student demand. An increase in the enrollment of foreign students would then imply a decrease in the number of accepted domestic students. Indirectly, the influx of a large number of foreign students can alter the incentives for domestic students to pursue other educational programs. Suppose, for example, that many foreign students enrolled in particular majors (such as STEM fields) choose to stay and work in the United States after their graduation, which may lower the entry level wages in the STEM-related occupations, then those occupations would become less attractive to domestic students.[12] Since American students are more flexible in the U.S. labor market, they would shift away from applying to programs in educational disciplines where many foreign students cluster. Therefore, both of these two channels lead to a crowd-out effect of foreign students on domestic students. It is noteworthy that the direct channel of the crowd-out effect is specific to a particular university, while the indirect channel of the crowd-out effect is the result of an economy-wide supply response which affects all universities. In the remaining part of this section, I focus on the changes that occur in domestic enrollment within a particular university resulting from the increase in the number of foreign students. Any economy-wide fluctuations, therefore, will be netted out.

Although the influx of foreign students could potentially crowd out domestic students through constraints in the demand for students, other channels may actually expand the number of domestic students as the size of the foreign student population increases. Section 2.2 illustrates that foreign

[12] Borjas (2003) and Borjas (2009) provide evidence on the earning impact of immigration and foreign students in the U.S. labor market. Freeman et al. (2001) describe the shifts in the bioscience job market as the consequence of the influx of foreign students.

students tend to pay a higher fraction of their undergraduate education, so an institution's financial condition could therefore be improved following an influx of foreign students. Institutions could, theoretically, utilize the revenue collected from foreign students to provide more opportunities for domestic students. Since demand constraints and the income effect would work in different directions, the net enrollment effect of foreign students on domestic students is ambiguous in theory.

While the financial condition of American institutions could be improved due to the additional source of revenue from foreign students, the consequences following such economic benefits on institutional financial indicators, however, are less clear-cut. On the one hand, if the foreign student supply exceeds a school's demand, and the school believes that it is easier and faster to collect tuition and fees from international students, the school will simply increase tuition and fees. Alternatively, if economic gains from foreign undergraduate students are sufficiently large, then a school might be able to increase the amount of institutional financial aid for accepted students and/or salaries for faculty and staff. The intuition behind this argument is that most research colleges in the U.S. are viewed as optimizing school quality or productivity (Hoxby (2002)). As a result, any excess of revenue above costs would be used to increase financial aid for qualified students and/or salaries for faculty and staff, because college quality is usually jointly determined by student quality and faculty quality which are subject to school resources.

Given the theoretical ambiguity of the impacts of foreign students on domestic enrollment and institutional financial outcomes, in the following analysis I will discuss an empirical identification strategy to investigate how the influx of foreign undergraduate students affects the U.S. higher education sectors in various aspects.

4 Data

The core data in this analysis comes from the Integrated Postsecondary Education Data System (IPEDS) from 2001 to 2013. For each year, institutions report the number of students enrolled by race and residency status, both at the undergraduate and the graduate level, tuition/fees

charged, institutional grant aid offered, average salaries for faculty and staff, and other institutional characteristics.[13]

The empirical study focuses on the impact of changing immigration among undergraduate programs. Ideally, I would like to collect information on the number of Chinese undergraduate students enrolled at a particular program in a particular year and examine how the influx of Chinese undergraduate students affects institutional outcomes. However, in the IPEDS database, schools do not report the number of students by country; they only report the enrollment information by residency status. Therefore, I use the supply shock of Chinese undergraduate students to generate variation in the number of nonresident aliens (which, for simplicity, I will refer to as "foreign students"), and examine the effects of foreign undergraduate students on U.S. institutions.[14] Given that China is the biggest source of foreign students in America, it is reasonable to anticipate that a sudden and dramatic increase in the number of Chinese students would also be reflected in an increase in the number of nonresident aliens. Figure 3 illustrates the total number of Chinese undergraduate students and the total number of all international undergraduate students in all fields studying in American institutions between 2000 and 2013. Although not perfectly correlated, the patterns of these two figures are very similar, suggesting that the supply shock induced by Chinese students led to a sharp increase in the number of all foreign students. Specifically, from 2005 to 2013, the number of Chinese undergraduate students increased by 101,246, while the number of all foreign undergraduate students increased by 131,506.[15] That is to say, about 77 percent of the increase in foreign undergraduate students was driven by Chinese students.

Interestingly, the increase in the number of foreign undergraduate students was not felt equally across all types of colleges. Figure A.1 depicts foreign enrollment by college type from 2001 to 2013 based on Carnegie Classification 2000 (Research, Masters, Baccalaureate and others). While research universities experienced the majority of the influx of foreign students after 2006, other

[13]The completion of all IPEDS surveys is mandatory for institutions that participate in or are applicants for any federal student financial aid program.

[14]Nonresident alien refers to a person who is not a citizen or national of the United States and who is in this country on a visa or temporary basis.

[15]In 2005, the number of Chinese undergraduate students and the number of total foreign undergraduate students in the U.S. were 9,304 and 239,218, respectively; however, in 2013, these figures became 110,550 and 370,724, respectively.

types of colleges saw little fluctuation in foreign enrollment. Therefore, in this paper, I restrict my attention to U.S. research universities that provide 4 years or more of higher education.[16] I calculate the total enrollment at each institution by counting full-time first-time undergraduate students. To get a balanced panel, I exclude institutions that only appear in pre-shock or post-shock periods. By construction, I get 246 institutions and observe the data at the institution-year level, so in total, the panel tracks the institutional outcomes of 246 institutions over 13 years. Figure 4 presents the average number and the average fraction of full-time first-time foreign undergraduate students at each research university over the 2001 and 2013 period.[17] The figure clearly shows an increase in both the number and the fraction of foreign undergraduate students at U.S. research institutions after 2006. Detailed main variable descriptions and source information are shown in Table A.1 and summary statistics are shown in Table A.2.

The trends in Figure 4, however, only show the time-series variation but ignore the possibility that there exists heterogeneity in the sample of American institutions. There is little reason to suspect all institutions are impacted the same. Inspired by Card and DiNardo (2000) and Card (2001), in this analysis, I assume that institutions that had a higher number of foreign students prior to 2006 are likely to have a larger influx of international students after the shock. In Figure A.2, I present a plot of the average number of foreign undergraduate students between 1998 and 2000 (prior to the sample period) against the average number of foreign undergraduate students between 2006 and 2013 (after the shock). As predicted above, there is a strong positive association between the number of previously enrolled foreign students and the number of newly enrolled foreign students. Therefore, in this analysis, I utilize both cross-time and cross-sectional variations to generate plausibly exogenous variations in the number of foreign students. First, I use the changes in visa policies and exchange rate regimes in 2006 to generate pre-shock and post-shock periods. Second, I use historical levels of foreign students across universities as a shift-share instrument to predict enrollment patterns after 2006.

[16] Based on Carnegie Classification 2000, research universities refer to research universities (extensive) and research universities (intensive).

[17] The fraction of foreign student is calculated by dividing the total number of nonresident aliens by the total number of students.

5 Empirical Methods

The empirical equation of interest is a two-stage least square model that is identified with a difference-in-differences specification. Let E_{ut} denote institutional outcomes of interest at school u in time t, and I am interested in the domestic enrollment and institutional financial outcomes. Let F_{ut} denotes the respective number of full-time first-time foreign undergraduate students. The OLS regression model used to capture the impacts of the influx of foreign undergraduate students on institutional outcomes is given by:[18]

$$E_{ut} = \delta_u + \varphi_t + \beta F_{ut} + \varepsilon_{ut} \tag{1}$$

Where δ_u represents a vector of university fixed effects, which is used to net out any time-invariant university-specific factors that may affect institutional outcomes; φ_t represents a vector of year fixed effects, which is used to net out any time-specific factors that are common to all universities and determine outcomes of interest. The coefficient of interest is β, which measures the effects on institutional outcomes within a particular university when that university enrolls one additional foreign student. The final term ε is the idiosyncratic error term. The standard errors are clustered at the university level. It is important to note that time-invariant difference between larger universities and smaller universities in many dimensions does not invalidate the identification strategy since level effects are differenced out by including university fixed effects.

Estimation of Equation 1 by the standard OLS regression may lead to biased estimates of β for several reasons. If universities recruited more foreign students because they faced a decline in the demand of qualified domestic students or because they became less generous in offering financial support, then the reverse causality would contaminate the estimates of β. Therefore, in order to overcome the endogeneity bias, an instrumental variables strategy is necessary.

Card and DiNardo (2000) and Card (2001) first argued that new immigrants are more likely to gravitate towards enclaves established by earlier immigrants from the same country, and since then

[18] In this analysis, all variables are measured at levels. The baseline specification (Equation 1) is consistent with existing literature in this field (Borjas (2004)).

their instrument has been used to explore the impacts of immigration on a variety of outcomes in more recent papers (Wozniak et al. (2012),Peri et al. (2015)). Similarly, in this paper, I instrument the number of full-time first-time foreign undergraduate students by the interactions of two terms: one, a continuous number of full-time first-time foreign undergraduate students between 1998 and 2000 at each university, and the other indicating the relative year to 2005. Therefore, the first-stage equation that relates the endogenous regressor to the instrumental variables and other control variables is:

$$F_{ut} = \delta_u + \varphi_t + \sum_{k=-4,k\neq 0}^{8} \alpha_k (BeforeForeign_u * PostYear_{k,t}) + \varepsilon_{ut} \tag{2}$$

In this equation, $BeforeForeign$ equals the historical number of full-time first-time foreign undergraduate students at each institution between 1998 and 2000; and $PostYear$ are indicator variables equaling one if the year is k years relative to 2005. The omitted category is the last year prior to the supply shock (2005).[19] Since the specification has a set of year dummies and institution dummies, α denote difference-in-differences coefficients. However, unlike the standard difference-in-differences model, instead of using simple "treatment" and "post" indicators, I use a continuous measure of the number of initial foreign undergraduate students at each school and a series of year-since-supply shock dummies. The identification, therefore, could generate more variation and estimate more time dynamic effects.[20]

The validity of the instrumental variables relies on several assumptions that are fundamentally unprovable. First, the influx of foreign students cannot be endogeneously affected by the demand of top foreign student receiving institutions. Second, the instrumental variables do not affect institutional outcomes of interest through channels other than the increase in the number of foreign undergraduate students. The validity of the difference-in-differences instrumental variables and the robustness of the baseline results will be extensively discussed and tested in the Section 7.

[19]For example, if the year is 2004, then k=-1; if the year is 2006, then k=1; if the year is 2007, then k=2.

[20]In section 7.2, I show that the regression results are robust to the standard difference-in-difference model and the model ignoring time series information.

6 Results

6.1 First-Stage Results

An interesting starting point for empirical analysis is to investigate the extent that the foreign supply shock affects the enrollment of foreign undergraduate students at different institutions. Before jumping into regression results, it is instructive to present a difference-in-differences graph by two distinct groups: universities with many foreign students before the shock and universities with few foreign students before the shock. To split the sample into two equal groups, institutions with many earlier foreign students are defined as 123 universities that had more than the median number of full-time first-time foreign undergraduate students between 1998 and 2000, and correspondingly, the other 123 universities with few earlier foreign undergraduate students are in the residual group.[21] From Figure 5, we can see increasing trends in the average number of foreign undergraduate students enrolled in U.S. universities after 2006. The increase in foreign students is significantly larger at universities with many initial foreign student populations, suggesting that these universities are more greatly affected by the supply shock, while institutions with few initial foreign students are less affected. However, the differences between these two groups illustrated in the figure might be sensitive to the cutoff that I choose to split the sample. It is also important to note that the graphic representation might understate the variation. Therefore, rather than just simply dividing the sample into two groups, I report the regression results of Equation 2.

Table 1 displays the first-stage regression coefficients of the interaction terms $BeforeForeign$ and $PostYear$ (α_k in Equation 2). Column (1) contains the regression results on the entire sample. However, the average effect may mask heterogeneous effects across institutions with different characteristics, so from columns (2) through (5), I present the first-stage results separately by the type and ranking levels of institutions (ranked by the U.S. News, 2015). "Higher ranked" are schools whose rankings are among the top 100, while "lower ranked" are schools whose rankings are above 100 or have no rankings. Results in Table 1 show that while the coefficients in the

[21] Table A.3 lists the top 30 research universities that enrolled the most and fewest full-time first-time foreign undergraduate students between 1998 and 2000.

pre-shock periods are negative, small in magnitude, and do not present a particular trend, all of the coefficients in the post-shock periods are positive, of larger magnitude, and present an increasing trend. This implies that the difference in the foreign enrollment between highly affected institutions and less affected institutions is increasing over time. The coefficients in column (1) could be interpreted as schools having one more foreign student between 1998 and 2000 would enroll an extra 0.029 more foreign students in 2006, an extra 0.060 more in 2007 and an extra 0.124 more in 2008. Separate regressions across the type and ranking levels of institutions reveal a similar pattern. The thirteenth row of Table 1 displays the Cragg-Donald Wald F-statistics associated with the coefficients on the instrumental variables in the first-stage equation.[22] Except for "lower ranked" schools, all other Cragg-Donald Wald F statistics are at least above the Stock and Yogo (2001)'s critical value at the 10 percent level, suggesting that other than lower ranked schools, weak instruments are not a particular concern in this analysis.[23]

Figure 6 graphically presents the first-stage coefficients (solid lines) along with their 95 percent confidence intervals on the year-since-supply shock indicators, with the last year before the supply shock (2005) as the reference category (t=0).[24] As the figure shows, the coefficients are small in magnitude in the pre-shock periods with no obvious trend. The coefficients in the post-shock periods, however, are positive, larger in magnitude, and increasing over time. The first-stage results, therefore, confirm that institutions with many earlier foreign students saw a greater influx of new foreign students after 2006.

[22]If the number of instruments exceeds the number of endogenous regressors, a simple F-test on the instruments is not reliable. Alternatively, I use the Cragg-Donald F-statistics and compare the Cragg-Donald F-statistics to the Stock and Yogo (2001)'s critical values to test for weak instruments.

[23]Stock and Yogo (2001)'s critical values for one endogenous regressor with twelve instruments at the 5 percent and the 10 percent level are 21.01 and 11.52, respectively

[24]Because the first-stage results are not significant for "lower ranked" schools, I do not plot the first-stage coefficients for "lower ranked" universities.

6.2 Enrollment Effects

6.2.1 Main Results

The results above indicate that the foreign supply shock had a disproportionate impact on American research universities: foreign students are more likely to be enrolled at institutions with more initial foreign students. The next thing to consider is the effect of this foreign influx on domestic enrollment at American universities using the instrumental variables (IV) estimation. Table 2 reports the second-stage coefficient β after using the number of full-time first-time domestic undergraduate students enrolled at school u in year t as the dependent variable and instrumenting the number of full-time first-time foreign undergraduate students by $BeforeForeign$ and multiple year dummies (see Equation 2). Column (1) reports the regression results on the full sample, and columns (2) through column (4) report the regression results based on the type and ranking levels of schools.[25]

The estimated coefficient in column (1) is -0.53 (with a standard error of 0.47) and is statistically insignificant, indicating that the crowd-out effect of the enrollment of foreign students on the enrollment of domestic students is imprecise in the sample of all schools. However, this aggregate correlation masks a great deal of dispersion across different types of institutions. Results in columns (2) through (4) suggest that although there is little evidence of a crowd-out effect on domestic students at public schools, the crowd-out effect is particularly strong at schools with higher rankings. In fact, the coefficient on the domestic enrollment at higher ranked universities is -1.29 (with a standard error of 0.54), indicating that I cannot reject the null hypothesis that the crowd-out is one-for-one at these higher ranked universities.

Figure 7 illustrates the variation that underlies the regression results focusing on higher ranked universities. The enrollment of domestic undergraduate students show differential trends between universities with many earlier foreign students and universities with few earlier foreign students after the supply shock. While institutions with few earlier foreign students show a consistently increasing trend in domestic enrollment over time, institutions with many earlier foreign students

[25] Because the first-stage results are not significant for "lower ranked" schools and the weak instrument cannot give us reliable second stage estimate, I do not report the second-stage results for this group.

see a stagnant pattern in domestic enrollment after 2006. Therefore, consistent with the regression results, the figure documents the relative decline in the number of domestic undergraduate students at institutions with many earlier foreign students.

To summarize, the results in Table 2 suggest that in the top-100 research universities, there exists a significant crowd-out effect of foreign undergraduate students on domestic undergraduate students, with the point estimate close to negative one. In other types of universities, the crowd-out effect is estimated to be smaller, but given the estimates for these other groups are imprecise, I cannot reject the null that crowd-out is zero or one.

6.2.2 Constraints In the Demand for Students

In this section, I examine whether constraints in the demand for students are a possible explanation behind the crowd-out effect in higher quality schools. Recent studies (Lovenheim (2011), Barr and Turner (2013), Kim (2014))acknowledge that changes in enrollment are jointly determined by changes on both the supply for students and the demand for students. Some universities experience limited adjustments in student quantity when faced with a supply shock due to various constraints in campus size, faculty resources, government subsidies, and prestige. Therefore, if in the face of a student supply shock, a university is less able or willing to respond by increasing class size, a crowd-out is more likely.

In order to investigate this mechanism, I use a university's historical enrollment pattern between 1991 and 2000 to measure whether it is subject to more constraints in the demand for students. In practice, I compare schools between two groups–schools with historically stable enrollment patterns and schools with historically fluctuating enrollment patterns. I use two measurement to distinguish whether a school has a historically stable (or fluctuating) enrollment pattern. The first measurement is based on the percentage change in total undergraduate enrollment.[26] I consider a school with a historically stable enrollment pattern as one with a ten-year percentage change between 1991 and 2000 smaller than a change at the lower tertile level. Correspondingly, I consider

[26]Total undergraduate enrollment means the total number of full-time first-time undergraduate students. The percentage change is in absolute value.

a school with a historically fluctuating enrollment pattern as one with a ten-year percentage change between 1991 and 2000 larger than a change at the upper tertile level. However, enrollment might fluctuate year-to-year, which therefore requires a second measurement of enrollment patterns. This second measurement is based on the coefficient of variation of undergraduate enrollment. Similarly, if a school's coefficient of variation of undergraduate enrollment is smaller than the lower tertile level, then I consider it as a school with historically stable pattern. If a school's coefficient of variation of undergraduate enrollment is larger than the upper tertile level, then I consider it as a school with a historically fluctuating pattern. Schools with historically stable enrollment patterns are assumed to have more constraints in the demand for students than schools with historically fluctuating enrollment patterns.

The results of exploring the mechanism behind the crowd-out effect through constraints in the demand for students are presented in Table 3 and Table A.4. To simplify the exposition, I will mainly discuss the coefficients summarized in Table 3, which uses the ten-year percentage change in undergraduate enrollment to measure a school's enrollment pattern. Results in columns (1) and (2) show that the coefficient on domestic students is only negative and statistically significant at universities that are subject to more constraints, and I cannot reject the null that the crowd-out effect at universities with higher constraints in the demand for students is one-for-one. In columns (3) and (4), I focus on higher quality (top-100) universities. Among the top-100 universities, 41 belong to schools with more constraints based on the above classification criteria, while 25 belong to schools with less constraints. Results in columns (3) and (4) yield a similar conclusion, suggesting that among higher quality schools, the crowd-out effect is much stronger at universities that are subject to more constraints in the demand for students, and the coefficient on domestic students at these universities is close to negative one. Regression results using an alternative definition of historically stable (or fluctuating) enrollment patterns are presented in Table A.4. Not surprisingly, the estimated coefficients also show that the crowd-out effect only exists at universities with more constraints. In sum, the regression results in Table 3 and Table A.4 support the hypothesis that constraints in the demand for students are an important channel to drive the crowd-out effect at higher quality schools.

6.2.3 Admission Standards

After the foreign student supply shock, U.S. institutions faced much larger application pools, which may have affected their admission standards. To test this, I run the two-stage least square equation using the SAT 25th verbal/math percentile score and SAT 75th verbal/math percentile score as dependent variables, with corresponding results shown in Table 4. Although the coefficients on the SAT 25th and 75th percentile verbal scores are positive, they are either statistically insignificant (SAT 25th verbal scores) or only marginally statistically significant (SAT 75th verbal scores). The coefficients on the SAT 25th and 75th percentile math scores are positive, larger in magnitude and at least statistically significant at the 5 percent level. The regression results suggest that the SAT verbal scores of newly accepted foreign students are comparable to their American counterparts, but the SAT math scores of newly accepted foreign students are higher than their American peers. The empirical results, therefore, imply that admitting more foreign undergraduate students has resulted in an increase in admission standards at American universities, at least measured by SAT math scores.

6.3 Effects on Institutional Financial Outcomes

In this section, I investigate the impacts of the influx of foreign undergraduate students on institutional financial outcomes. There is limited financial data in the IPEDS data, but I will focus on four variables: tuition for full-time first-time undergraduate students, fees for full-time first-time undergraduate students, the average amount of institutional grant aid received by full-time first-time undergraduate students, and the average salaries for equated 9-month instructional staff. The pricing of higher education in the United States is completely different between private and public institutions. Private universities do not differentiate tuition/fees by state residency status of students. In contrast, public universities charge discounted tuition/fees for in-state residents, and non-discounted tuition/fees for out-of-state residents and foreign students. Therefore, I distinguish institutional tuition and fees by two types: discounted tuition/fees at public universities and

non-discounted tuition/fees at both public universities and private universities.[27,28] It is important to note that both discounted and non-discounted tuition/fees in this paper are list (sticker) prices, but discounted tuition/fees are discounted prices charged by public universities only for in-state residents.

Columns (1) and (2) of Table 5 report the estimated second-stage coefficients using different types of tuition as dependent variables. While the point estimate on non-discounted tuition is large and statistically significant at the 1 percent level, the point estimate on discounted tuition at public schools is of a smaller magnitude and is only marginally statistically significant. Columns (3) and (4) of Table 5 represent the results on school fees, and both coefficients are very small in magnitude and statistically insignificant. The results indicate that the influx of foreign undergraduate students has little impact on fees charged by American universities, but an additional foreign undergraduate student would lead to a 10-dollar increase in non-discounted tuition. The fact that this increase is much smaller on discounted tuition at public schools but particularly larger on non-discounted tuition is acceptable because any change in discounted tuition at public universities faces complicated political hurdles and is subject to state and local legislators' regulation. Therefore, public universities cannot easily increase discounted tuition for in-state residents as much as non-discounted tuition for out-of-state residents in response to market forces.[29]

Because foreign undergraduate students are more likely to pay full tuition, their entrance might enable universities to increase the amount of institutional financial aid for students and/or salaries for faculty and staff. The economic gains would be, in turn, beneficial for accepted domestic students and university faculty and staff.[30] In order to examine such a potential effect, I run the regressions using the average amount of institutional grant aid and the average salaries for

[27]Fees are fixed sum charged to students for items not covered by tuition and are required of such a large proportion of all students that a student who does not pay the charge is an exception.

[28]In other words, discounted tuition/fees mean in-state tuition/fees, while non-discounted tuition/fees include out-of-state tuition/fees at public universities and tuition/fees at private universities.

[29]In-state tuition/fees at public universities are regulated by state and local governors because the state and local appropriations are the largest revenue source for public universities. Data from the State Higher Education Executive Officers association suggest that in 2009, 58 percent of public universities' operating revenue are from state appropriations.

[30]An alternative variable of interest is the net price for students, however, the net price data are not available in the pre-shock periods.

instructional staff as dependent variables, with estimates presented in columns (5) and (6) of Table 5. The point estimate in column (5) is 12.34 (with a standard error of 5.64), in other words, one extra foreign student leads American research institutions to increase the average amount of institutional grant aid for accepted undergraduate students by roughly 12 dollars. The point estimate in column (6) is also positive but is only marginally statistically significant. The results are therefore supportive of the argument that colleges are able to increase the average amount of institutional grant aid for accepted students. Given the fact that the magnitude of the coefficients on non-discounted tuition and on institutional grant aid are both positive and of similar magnitudes, for accepted domestic students who receive institutional grant aid, the increase in non-discounted tuition can be at least offset by the increase in institutional grant aid.

It is instructive to illustrate the raw data that underlies results on institutional financial variables. Figure 8(a) and Figure 8(b) plot non-discounted tuition and institutional grant aid for accepted students by two types of institutions over time. The regression results in Table 5 are consistent with the raw data that are illustrated in Figure 8.

7 Robustness Checks

7.1 Validity of the Instrumental Variables

In order to provide consistent estimates, the instrumental variables must satisfy the exclusion restriction in that it only affects institutional outcomes through foreign undergraduate students. Although the exclusion restriction is fundamentally untestable, in this section I provide evidence that rules out several first-order concerns and demonstrates that the baseline results are robust across different specifications.

The instruments used in this paper are derived from the interaction of two components–a university's historical presence of foreign undergraduate students between 1998 and 2000, and the foreign student supply shock induced by Chinese students after 2006. Therefore, each component should be uncorrelated with other factors that have impacted domestic enrollment and institutional financial variables.

Drop the Great Recession Observations: If institutions with and without many earlier foreign students behaved quite different in the Great Recession (2007-2010). For example, during the Great Recession, "tuition freezes" were commonly implemented in several states. Under the "tuition freezes" agreement, in order to increase the funding from the state, institutions agreed not to increase tuition for a certain period. If institutions with many earlier foreign students switched from attracting foreign students to domestic students and stopped increasing their tuition in order to obtain the government funding during the Great Recession period, it would lead to biased estimates of β. One possible solution is to re-run all 2SLS regressions excluding observations in years 2007-2010, with results presented in Table 6.[31] After excluding observations in years 2007-2010, the instrumental variables still maintain their statistical power at the first-stage, and the second-stage results are very comparable to the baseline results in Table 2 and Table 5.[32]

Drop Ten Universities: A second concern for this model is that the foreign supply shock induced by Chinese students after 2006 might not be completely supply driven, but partially demand induced since some large universities with a high number of earlier foreign students might have incentives to lobby the government to relax the visa policies for international students. If that was the case, the foreign supply shock for education is not completely exogenous to each individual institution, resulting in a bias of the IV estimates. Figure A.3 presents the distribution of the number of full-time first-time foreign undergraduate students between 1998 and 2000 across American research universities. The data show that there do exist some universities that enrolled a significant number of foreign undergraduate students between 1998 and 2000. In order to alleviate this concern, I run the regressions by omitting ten universities that enrolled more than 400 full-time first-time foreign undergraduate students between 1998 and 2000.[33] Table 7 reports the second-stage results using the interaction term $BeforeForeign$ and a series of year dummies as IV when excluding ten universities. Here I do not show first-stage coefficients, but I display the Cragg-

[31] Due to the space limit, I only report the robustness checks of the point estimates that are significant in Table 2 and Table 5. However, I also conduct sensitivity analysis on other institutional outcomes of interest, and the results are comparable to my baseline results.

[32] All Cragg Donald F statistics pass the weak instruments test at least the 10 percent level.

[33] These ten universities are Purdue University, Boston University, University of Michigan, University of Texas at El Paso, University of Pennsylvania, Cornell University, New York University, Northeastern University, University of Wisconsin-Madison and University of South California.

Donald Wald F test in the second row. Most coefficients on institutional outcomes are similar to the main results in Table 2 and Table 5. However, if I use the enrollment of domestic students as the dependent variable at higher ranked universities, the coefficients change from being significant to being imprecise.

Account for School Size Differences: If universities with few earlier foreign students are much smaller than universities with many earlier foreign students, this raises the concern that universities with few earlier foreign students might not provide a credible comparison group. By simply comparing the total enrollment between 1998 and 2000 at universities with many earlier foreign students to that at universities with few earlier foreign students, I find that on average, universities with many earlier foreign students enrolled approximately 30 percent more full-time first-time foreign students than universities with few earlier foreign students. In the baseline specification, I include university fixed effects to net out time-invariant differences between larger schools and smaller schools, but the concern still exists if there are time-varying factors which affect larger schools and smaller school differently. I propose two ways to overcome this problem. First, I allow universities with different pre-shock sizes to follow different trends, with the results reported in Table 8. Specifically, in columns (1) to (3), I divide the sample into 22 groups based on their initial total number of full-time first-time undergraduate students between 1998 and 2000, with each group having 1000-student bands, I then incorporate group-specific linear time trends into the baseline specifications. In columns (4) to (6), I conduct an even more demanding test by adding institution-specific linear time trends into the baseline specification. The regression results, however, show that allowing universities with different initial school sizes to follow different trends would not significantly change the baseline results.[34]

A second potential way to address this worry is to run separate regressions by the size of a university. Therefore, I divide institutions into equal three categories: large-sized schools, mid-sized schools and small-sized schools. Universities in each category are those whose total number of full-time first-time undergraduate students between 1998 and 2000 are within their tertile.[35]

[34] I also conduct a similar analysis by adding group or institution specific quadratic time trends. The regression results presented in Table A.5, which are comparable to the results in Table 8.

[35] Because I have 246 universities in the sample, each category contains 82 universities.

Universities are more comparable within their size group after dividing them into subcategories. I run separate IV regressions using institutional variables as outcomes for large-sized schools and small-sized schools, with the second-stage results along with Cragg Donald F statistics reported in Table 9.[36] The coefficient on the number of domestic students is only statistically significant at large-sized schools, with the point estimate close to negative one, suggesting that there exists an approximately one-for-one crowd-out effect at large-sized schools. Coefficients on non-discounted tuition and institutional grant aid are all positive and statistically significant at both large-sized and small-sized universities, but the magnitude of coefficients on non-discounted tuition and institutional grant aid are much greater at small-sized schools, suggesting that for small-size schools, the marginal economic benefit of admitting one extra foreign student is of particular significance.

Spillovers from Graduate Programs: A fourth potential concern is due to the fact that visa relaxation policies and exchange rate regimes affect both undergraduate and graduate students. If a university experienced an influx of foreign graduate students in addition to foreign undergraduate students after 2006, and there existed financial spillovers from graduate programs (i.e. tuition used collected from masters programs to pay institutional grant aid or salaries), then the effects I find in the previous context may be biased. To address this problem, I run Equation 2 using the number of full-time first-time foreign graduate students as the dependent variable, with corresponding coefficients displayed in Figure 9(b). In comparing coefficients in Figures 9(b) and 9(a), we find that although universities with many initial foreign undergraduate students also experienced a larger increase in the foreign graduate enrollment after 2006, the coefficients in Figure 9(b) are only 1/3 to 1/10 the magnitude of those in Figure 9(a). This suggests that the foreign supply shock is much greater for undergraduate programs than for graduate programs. Therefore, even though the influx of foreign graduate students may affect baseline point estimates, its lack of significance suggests that it would not be an important driver of my results.

Domestic Student Supply: Another possible scenario that would violate the exclusion restriction is an institution attracting more foreign students while also becoming more/less popular among

[36]Because the first-stage results do not pass Stock and Yogo (2001)'s weak instruments test at the 10 percent level at mid-sized schools, I do not report the second-stage results of mid-sized schools.

domestic students due to institutional characteristics that are unrelated to the foreign supply shock. Ideally, I could check the number of domestic applications across universities over time to see whether this concern exists. Unfortunately, the IPEDS do not have information about the number of applications separated by domestic and foreign students, but I can use an indirect approach to examine this concern. Figure 10(a) shows the coefficients of running Equation 2 using the total number of applications as the dependent variable. Similar to the pattern in the baseline first-stage coefficients, while the coefficients are relatively small in magnitude and do not present an obvious trend in the pre-shock periods, the post-shock coefficients are positive, of larger magnitude, and have an increasing trend. Regression results suggest that institutions with many earlier foreign students also received a larger increase in the number of applications after the supply shock. To disentangle whether the relative increase in the number of applications is driven by foreign applicants or domestic students or both, I would need to know the enrollment rate by all students, foreign students, and domestic students, respectively.[37] Dividing the total number of full-time first-time students by the total number of applicants, I can get the overall enrollment rate; however, institutions do not typically report the enrollment rate by domestic/foreign students. By randomly selecting fifty universities in my sample and checking these institutions' enrollment statistics, I find the enrollment rate presented by domestic/foreign students from only a few universities.[38] Although enrollment rates differ across universities and years, the enrollment rate of foreign students is much lower than the overall enrollment rate: in particular, the foreign enrollment rate is typically only 1/2 to 1/10 of the overall enrollment rate. If I assume the foreign enrollment rate is 1/4 of the overall enrollment rate in my sample, then I could approximate the relative increase in the number of applications that are attributed to foreign applicants by dividing coefficients in Table 1 by the approximated foreign enrollment rate, with the approximated number of foreign applications presented in Figure 10(b). Comparing Figure 10(b) with Figure 10(a), we can see that they are very similar in patterns and magnitudes, implying that the increase in the number of applications is mainly driven by foreign applicants. Therefore, it seems that the do-

[37]Enrollment rate=Acceptance rate* Yield rate. Acceptance rate= number of students accepted/total applicants. Yield rate= number of students enrolled/number of students accepted.

[38]Enrollment information in these universities are reported in Table A.6

mestic applicant pool does not particularly change between universities with many earlier foreign students and universities with few earlier foreign students over time.

Pre-trends: Additionally, any difference-in-differences identification relies on the assumption that the treatment group and the control group behave similarly prior to the shock. I have two ways to test this assumption. First, some graphical presentations already allow for a partial test. In Figure 6, if the foreign supply shock is unrelated to underlying trends and institutions do not respond before the supply shock, there should be no trend in the $PostYear_k$'s for $k \leq 0$. Figure 6 shows that there is no apparent trend in the pre-shock coefficients in any type of university. In Figure 7 and Figure 8, if institutions with many earlier foreign students and institutions with few earlier students did not behave differently prior to the shock, the raw data of domestic enrollment and financial outcomes in these two types of universities should be parallel to each other in the pre-shock periods. From Figure 7 and Figure 8, I cannot visualize a particular difference in trends between these two types of institutions before the supply shock.

Second, I present a placebo test only using the pre-shock periods of the data to ensure that it is unlikely that the difference in prior trends explain my findings. Specifically, I run Equation 2 by moving the foreign supply shock from 2006 to 2003, and using different outcomes of interest as dependent variables. If there were no differential pre-trends among universities, it is expected that the estimated coefficients of the new interaction term would have a small magnitude and be statistically insignificant. Table 10 reports the results for the placebo test, and as expected, all of the coefficients are close to zero and most of them are statistically insignificant.

7.2 Other Identification Strategies

In addition to the baseline specification, I conduct the analysis using different identification strategies. First, in addition to the cross-year and cross-university variations in foreign inflows, I exploit a third important characteristic of foreign students: foreign students are more likely to concentrate on some majors than others, so I construct a two-stage least square model that is identified with a triple-difference specification. Second, instead of using an event-study style equation, I implement a more standard difference-in-difference model as the first-stage, so the model is exactly identified.

Third, I use a model that ignores time series information to correct for serial correlation problem in a long panel. Finally, I create two alternative instrumental variables to further assess the robustness of the baseline results. In the following part of this section, I will discuss each identification strategy in detail.

7.2.1 A Triple-Difference Design

I create a triple-difference design by looking at the difference across majors at a given university. The advantage of using a triple-difference model over a difference-in-differences model is that the exclusion restriction is only violated if there exists time-varying differences between the more affected majors versus the less affected majors within a university that had differential effects on institutional outcomes. The IPEDS only report the enrollment information by residency status and major biennially, so in my sample I can gather the information about the undergraduate enrollment by residency status and major in 2002, 2004, 2006, 2008, 2010, and 2012. Figure A.4 depicts the number of full-time first-time foreign undergraduate students by major between 2002 and 2012. It shows that while the number of foreign undergraduate students experienced a sharp increase in business, engineering, mathematics and physical science after 2006, the number of foreign undergraduate students in biology/life science and education is stagnant. This phenomenon indicates that business, engineering, mathematics and physical science fields are more affected by the foreign supply shock after 2006. Therefore, I run the following regression using a triple-difference IV to capture the exogenous variation in the number of foreign students:

$$\begin{aligned} F_{uft} &= \sum_{k=-2,k\neq 0}^{3} \lambda_k (BeforeForeign_u * PostYear_{k,t} * Major_f) + \delta_u + \varphi_t + \upsilon_f \\ &\quad + major_f * \delta_u + shock_t * \delta_u + major_f * shock_t + \varepsilon_{uft} \end{aligned} \tag{3}$$

Where the instrumental variables here are the triple interactions of an indicator variable of whether the major is in a more affected field, a set of dummies of the year relative to 2006, and the continuous measure of the historical number of full-time first-time foreign undergraduate

students at each university between 1998 and 2000. Because I do not have enrollment information by major in 2005, the omitted group is the first year of the supply shock (2006). $Major$ is a dummy variable which equals one if the major is business, engineering, mathematics or physical science and 0 otherwise. $Shock$ is a dummy variable if the year is in or after 2006. The first-stage and second-stage results are reported in Table 11, separately for all universities and higher ranked universities. While pre-shock coefficients are negative and of small magnitude, post-shock coefficients are positive in the first-stage, suggesting that within a university, foreign students are more likely to be enrolled in the more affected majors after the shock.[39] The second-stage coefficients are comparable to the main results in Table 2: the coefficient is negative and is of larger magnitude among higher ranked universities, with the point estimate close to negative one.[40]

7.2.2 An Exactly Identified Difference-in-Differences Model

In my baseline analysis, I use an even-study style regression as the first-stage, so one endogenous variable (the number of foreign students) was instrumented by multiple instrumental variables ($BeforeForeign$ times different year-since-supply shock dummies). In this section, I use a more standard difference-in-differences model as the first-stage:

$$F_{ut} = \delta_u + \varphi_t + \Phi(BeforeForeign_u * PostYear_t) + \varepsilon_{ut} \tag{4}$$

Where instead of decomposing $PostYear$ into different year dummies relative to 2005, $PostYear$ is an indicator variable which equals one if the year is after 2005. The second-stage results using Equation 4 as the first-stage are presented in Table 12. Compared to the results in Table 2 and Table 5, the second-stage results with one instrumental variable and multiple instrumental variables are comparable.[41]

[39] Stock and Yogo (2001)'s critical value for a model with one endogenous regressor and four instruments is 10.83 at the 10 percent level.

[40] Because institutional financial outcome variables do not vary by major in the data, I cannot use a triple-differences design to examine the effects on institutional financial variables.

[41] The F statistics in the first-stage is close to or greater than 10.

7.2.3 Aggregating the Data

One limitation of the difference-in-differences strategy pointed out by Bertrand et al. (2004) is that due to the serial correlation problem, the standard error for the point estimate of interest could be severely understated.[42] One of the corrections in their paper to solve the serial correlation problem is to ignore time series information when calculating standard errors. I follow this recommendation by collapsing the data to pre-shock and post-shock periods and running regressions on the aggregated outcome variables in a panel of two periods. The results of this exercise are presented in Table 13. After the collapsing, the number of observations declines, but the second-stage results are similar to the baseline results in Table 2 and Table 5.

7.2.4 Alternative Instrumental Variables

I use two alternative instrumental variables (IV) specifications that depend on different assumptions. First, I follow Wozniak et al. (2012) and use the following IV for current foreign students: $IV = (\frac{F_{u,1998and2000}}{F_{1998and2000}}) * (F_t - F_{u,t})$, where the first term is an institution's historical (between 1998 and 2000) share of total foreign undergraduate students among all universities, and the second term is the subtraction of an institution's own inflow from total inflow. Similar to Card and DiNardo (2000) and Card (2001), this IV assumes that if there exists a supply shock, institutions with larger shares of foreign undergraduate students in the prior period are more likely to experience larger changes in the number of foreign undergraduate students. However, this IV also relies on the assumption that fluctuations in the number of foreign undergraduate students in the rest of the school, which are driven by factors exogenous to school u, drive the shocks to the changes in the number of foreign undergraduate students. Therefore, the corresponding first-stage that relates the endogenous regressor to the new IV is:

$$F_{ut} = \delta_u + \varphi_t + \rho(\frac{F_{u,1998and2000}}{F_{1998and2000}}) * (F_t - F_{u,t}) + \varepsilon_{ut} \tag{5}$$

The second-stage results of using the new IV are displayed in Table 14. The associated F

[42] For detailed information, please refer to Bertrand et al. (2004).

statistics in the first-stage equation is close to or above ten, indicating that the new IV has statistical power in the first-stage. Table 14 yields quite similar results to the main coefficients in Table 2 and Table 5.

Second, the baseline instruments assume that the initial number of foreign students at a school could predict the future flow, but one might be also interested in investigating if the initial fraction of foreign student at a school could also predict the future flow. In order to explore this possibility, I use the initial fraction of foreign students at a given university as a shift-share instrument, and the OLS equation of interest and the first-stage equation could be written as:

$$E_{ut} = \delta_u + \varphi_t + \beta \frac{F_{u,t}}{EnrollTotal_{u,t-1}} + \varepsilon_{ut} \tag{6}$$

$$\frac{F_{u,t}}{EnrollTotal_{u,t-1}} = \delta_u + \varphi_t + \alpha(\frac{BeforeForeign_u}{BeforeTotal_u} * PostYear) + \varepsilon_{ut} \tag{7}$$

where $BeforeTotal_u$ represents the initial total number of enrollment at school u between 1998 and 2000, and $EnrollTotal_{u,t-1}$ represents the total number of enrollment at school u in the previous year $t-1$. In Equation 6, if the dependent variable is the domestic enrollment, I divide the number of domestic student at school u in year t by $EnrollTotal_{u,t-1}$.[43] In this section, to simply the analysis, I implement a standard difference-in-differences model as the first-stage. Specifically, if a university's initial fraction of foreign students ($\frac{BeforeForeign_u}{BeforeTotal_u}$) is larger than the median level, it is considered as a university that is more affected by the supply shock. Correspondingly, if a university's initial fraction of foreign students is smaller than the median level, it is considered as a university that is less affected by the supply shock. Therefore, in Equqation 7, $\frac{BeforeForeign_u}{BeforeTotal_u}$ is a dummy variable which equals one if the school is more affected, and $PostYear$ is a dummy variable which equals one if the year is in and after 2006.

The regression results of doing this exercise are reported in Table 15. The first-stage coefficients(columns 1 & 3) are positive and statistically significant at the 1 percent level, suggesting that universities with a higher initial fraction of foreign students experience a large increase in the

[43]Because the instruments are standardized by the initial total enrollment, all other enrollment variables should be transformed in the same manner.

fraction of foreign enrollment after 2006. The second-stage point estimate on domestic enrollment at higher-ranked universities is -1.03 (with a standard error of 0.036), which indicates that a one percentage point increase in the fraction of foreign enrollment would lead to a one percentage point decrease in the fraction of domestic enrollment. Because both of foreign enrollment and domestic enrollment are simple standardization of enrollment levels, the point estimate also suggests that at higher-ranked universities, each additional foreign undergraduate student crowds out one domestic undergraduate student. The second-stage coefficients on non-discounted tuition and institutional grant aid are 792.07 (with a standard error of 329.16) and 1639.15 (with a standard error of 493.54), respectively, which mean that one percentage point increase in the fraction of foreign enrollment would lead to an approximately 800-dollar increase in non-discounted tuition, and an approximately 1600-dollar increase in institutional grant aid.

8 Conclusion and Discussion

This paper examines the impacts of the influx of foreign undergraduate students on the U.S. higher education system. My analysis exploited a quasi-experiment provided by the sudden supply shock of Chinese undergraduate students around 2006. I use data collected from the Integrated Postsecondary Education Data System (IPEDS), which provides detailed information at the institution year level. The data reveal that universities with a higher number of foreign undergraduate students prior to the shock experienced a larger influx of new foreign undergraduate undergraduate students after the shock.

I use the instrumental variables strategy to empirically identify the causal relationship between the enrollment of domestic students and the enrollment of foreign students. The regression results in this paper suggest that although there is an imprecise crowd-out effect of foreign undergraduate students on domestic undergraduate students at all schools, this crowd-out effect is particularly strong at higher ranked universities, approximately one-for-one. Exploration of the mechanism suggests that constraints in the demand for students at large selective universities is an important channel in explaining the crowd-out effect. I also find that the greater supply of foreign students

leads U.S. institutions to increase their admission standards, measured by SAT math scores. Additionally, I examine the impacts of the influx of foreign students on other institutional financial outcomes of interest. The empirical results indicate that the influx of foreign undergraduate students increases non-discounted tuition, but has little impact on school fees. Admitting more foreign undergraduate students allows a university to increase the average amount of institutional grant aid for accepted students.

Education is a cornerstone for a nation's development, and higher education plays a significant role in maintaining a country's long-run economic advantages. Since the U.S. is the largest host of foreign students in the world, examining the effects of the influx of foreign undergraduate students on American students and colleges has several implications.

The findings in this paper suggest that, from a domestic student's point of view, the influx of foreign students increases competition for coveted seats at top universities, which could negatively affect their long-term labor market outcomes such as career prospects and salary. From an institution's perspective, admitting more foreign students might have positive effects. First, more foreign students increase competition among applicants, allowing institutions to select more talented students. Second, as foreign students usually pay for a larger fraction of their education, an institution's financial condition would be better off following the influx of foreign students. It could potentially improve school quality by providing more institutional grant aid for accepted students. However, from a policy maker's perspective, the implication is more complicated, depending crucially on what happens to foreign students after they complete their undergraduate education. If these foreign students stay in the U.S. and make sizable contributions to the U.S. economy after their graduation, it is not a bad idea to reallocate resources to take advantage of the benefits created by those students. In contrast, if these foreign students leave the U.S. upon graduation, the benefits they bring will be short-lived. Additionally, the crowd-out effect could leave the U.S. labor market with a chronic shortage of highly-skilled workers, dwarfing any short-term gains from the foreign student influx.[44]

[44]The exodus of foreign students could be due to several reasons. On the one hand, the H1-B cap would force some highly-skilled immigrant workers to leave the U.S. because they cannot get legal working visa. Alternatively, the economic growth of foreign students' home countries would attract these highly educated students go back to

In sum, the rapid growth of foreign undergraduate students in the past decade has significant impacts on the U.S. higher education sector in many aspects. This paper focuses on the impacts at the institutional level, but due to data limitation, little is known about more general equilibrium effects, such as peer effects or student sorting, so future study could try to uncover the effects of foreign students on other aspects of U.S. society and economy.

work in their home countries. (Grogger and Hanson (2015))

References

Andrew Barr and Sarah E Turner. Expanding enrollments and contracting state budgets the effect of the great recession on higher education. *The Annals of the American Academy of Political and Social Science*, 650(1):168–193, 2013.

Marianne Bertrand, Esther Duflo, and Sendhil Mullainathan. How much should we trust differences-in-differences estimates? *Quarterly Journal of Economics*, 119(1), 2004.

Kelli Bird and Sarah Turner. College in the states: Foreign student demand and higher education supply in the us. *paper, Curry School of Education, University of Virginia*, 3, 2014.

George J Borjas. The labor demand curve is downward sloping: Reexamining the impact of immigration on the labor market. *The Quarterly Journal of Economics*, pages 1335–1374, 2003.

George J Borjas. Do foreign students crowd out native students from graduate programs? *NBER Working Paper Series*, page 10349, 2004.

George J Borjas. Immigration in high-skill labor markets: The impact of foreign students on the earnings of doctorates. In *Science and Engineering Careers in the United States: An Analysis of Markets and Employment*, pages 131–161. University of Chicago Press, 2009.

George J Borjas and Kirk B Doran. The collapse of the soviet union and the productivity of american mathematicians. *The Quarterly Journal of Economics*, 1143:1203, 2012.

George J Borjas, Kirk B Doran, and Ying Shen. Ethnic complementarities after the opening of china: How chinese graduate students affected the productivity of their advisors. *NBER Working Paper Series*, page 21096, 2015.

John Bound and Sarah Turner. Cohort crowding: How resources affect collegiate attainment. *Journal of public Economics*, 91(5):877–899, 2007.

John Bound, Sarah Turner, and Patrick Walsh. Internationalization of us doctorate education. Technical report, National Bureau of Economic Research, 2009.

John Bound, Breno Braga, Gaurav Khanna, and Sarah Turner. A passage to america: University funding and international students. 2016.

David Card. The causal effect of education on earnings. *Handbook of labor economics*, 3:1801–1863, 1999.

David Card. Immigrant inflows, native outflows, and the local labor market impacts of higher immigration. *Journal of Labor Economics*, 19(1):22–64, 2001.

David Card and John DiNardo. Do immigrant inflows lead to native outflows? *American Economic Review*, 90(2):360–367, 2000.

Pedro Carneiro, James J Heckman, and Edward J Vytlacil. Estimating marginal returns to education. *American Economic Review*, 101:2754–2781, 2011.

Kirk Doran, Alexander Gelber, and Adam Isen. The effects of high-skilled immigration on firms: Evidence from h-1b visa lotteries. *NBER Working Paper Series*, page 20668, 2014.

Susan M Dynarski. Does aid matter? measuring the effect of student aid on college attendance and completion. *NBER Working Paper*, (w7422), 1999.

Erica Field. Educational debt burden and career choice: Evidence from a financial aid experiment at nyu law school. *NBER Working Paper*, (w12282), 2006.

National Center for Education Statistics. Ipeds : Integrated postsecondary education data system.

Richard Freeman, Eric Weinstein, Elizabeth Marincola, Janet Rosenbaum, and Frank Solomon. Competition and careers in biosciences. *Science*, 294(5550):2293–2294, 2001.

Jeffrey Grogger and Gordon H Hanson. Attracting talent: Location choices of foreign-born phds in the united states. *Journal of Labor Economics*, 33(S1):S5–S38, 2015.

Caroline M Hoxby. Do immigrants crowd disadvantaged american natives out of higher education? *Help or Hindrance?: The Economic Implications of Immigration for African Americans: The Economic Implications of Immigration for African Americans*, page 282, 1998.

Caroline M Hoxby. School choice and school productivity (or could school choice be a tide that lifts all boats?). *NBER Working Paper*, (w8873), 2002.

Jennifer Hunt. The impact of immigration on the educational attainment of natives. Technical report, National Bureau of Economic Research, 2012.

Osborne Jackson. Does immigration crowd natives into or out of higher education? *Available at SSRN 2329298*, 2014.

William R Kerr, William F Lincoln, et al. The supply side of innovation: H-1b visa reforms and us ethnic invention. *Journal of Labor Economics*, 28(3):473–508, 2010.

Soobin Kim. College enrollment over the business cycle: The role of supply constraints. *Available at SSRN 2535811*, 2014.

Michael F Lovenheim. The effect of liquid housing wealth on college enrollment. *Journal of Labor Economics*, 29(4):741–771, 2011.

Stephen Machin and Richard Murphy. Paying out and crowding out? the globalisation of higher education. 2014.

Petra Moser, Alessandra Voena, and Fabian Waldinger. German-jewish emigres and us invention. *NBER Working Paper Series*, page 19962, 2014.

Institute of International Education. International students at all institutions, 2001/02-2014/15. *Open Doors Report on International Educational Exchange*, 2001-2015.

Giovanni Peri, Kevin Shih, and Chad Sparber. Stem workers, h-1b visas, and productivity in us cities. *Journal of Labor Economics*, 33(3 pt 2), 2015.

Jesse Rothstein and Cecilia Elena Rouse. Constrained after college: Student loans and early-career occupational choices. *Journal of Public Economics*, 1(95):149–163, 2011.

Kevin Y Shih. The impact of international students on us graduate education. Working paper, 2015.

Douglas Staiger and James H Stock. Instrumental variables regression with weak instruments. *Econometrica: Journal of the Econometric Society*, pages 557–586, 1997.

James H Stock and Motohiro Yogo. Testing for weak instruments in linear iv regression. 2001.

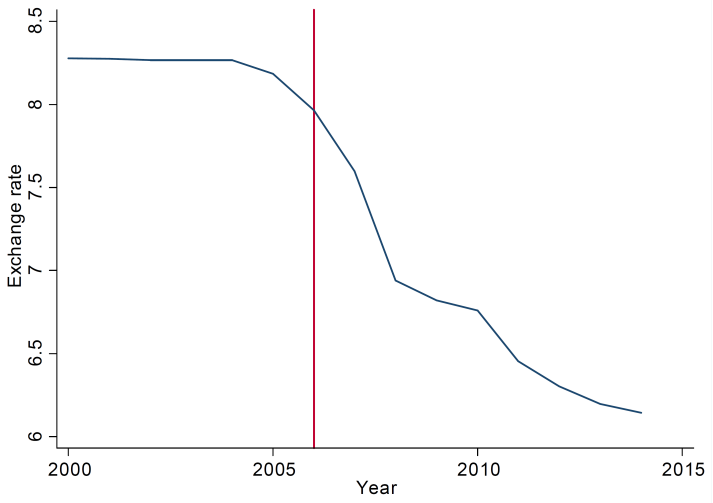
Wilbert van der Klaauw et al. Estimating the effect of financial aid offers on college enrollment: A regression-discontinuity approach. *International Economic Review*, 43(4):1249–1287, 2002.

You-Qin Wang. Student attacks against teachers: The revolution of 1966. *Issues & Studies*, 37 (2):29–79, 2001.

Gordon C Winston et al. Subsidies, hierarchy and peers: The awkward economics of higher education. *Journal of Economic Perspectives*, 13(1):13–36, 1999.

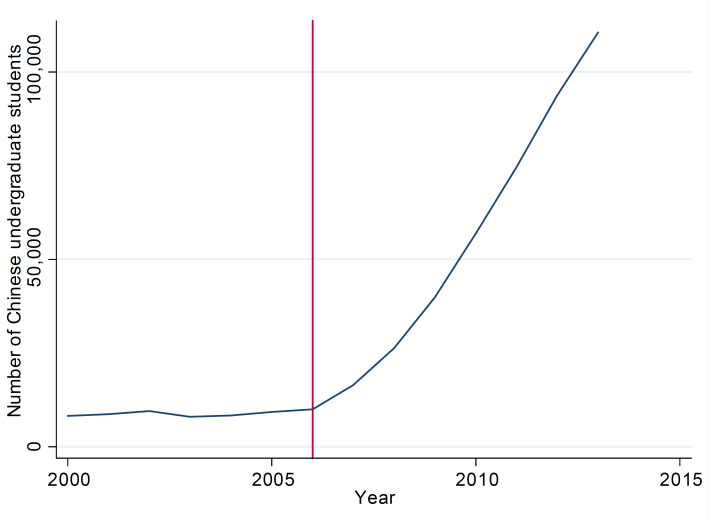
Abigail Wozniak, Thomas J Murray, et al. Timing is everything: Short-run population impacts of immigration in us cities. *Journal of Urban Economics*, 72(1):60–78, 2012.

Figure 1: Exchange Rate of U.S. Dollar against Renmimbi, 2000-2013



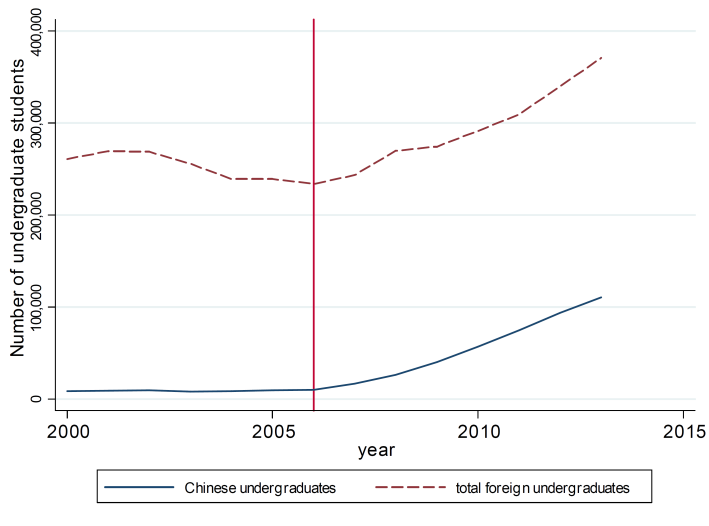
Notes: source: `http://www.oanda.com/lang/cns/currency/historical-rates/`

Figure 2: Number of Chinese Undergraduate Students in American Institutions, 2000-2013



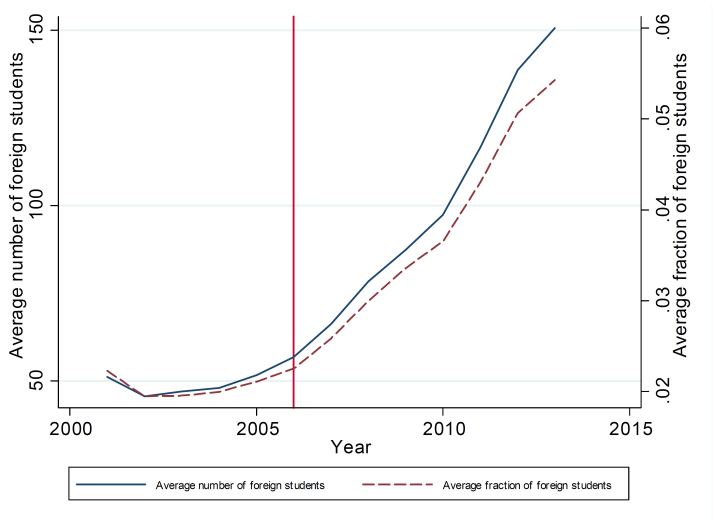
Notes: Data is collected from Open Doors Data, *Institute of International Education*

Figure 3: Number of Chinese and All Foreign Undergraduate Students



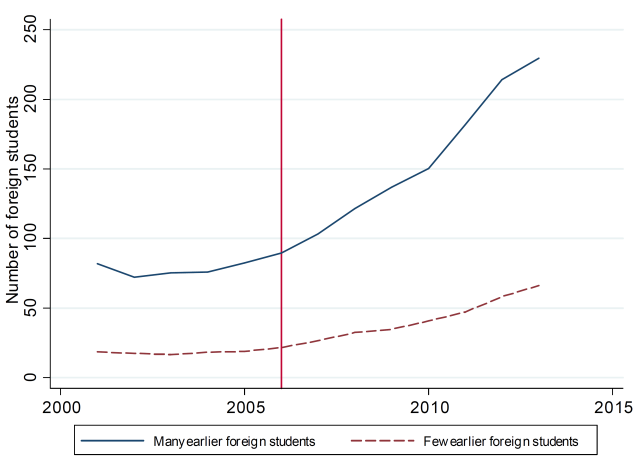
Notes: Data is collected from Open Doors Data, *Institute of International Education*

Figure 4: Number and Fraction of Foreign Undergraduate Students at American Research Institutions



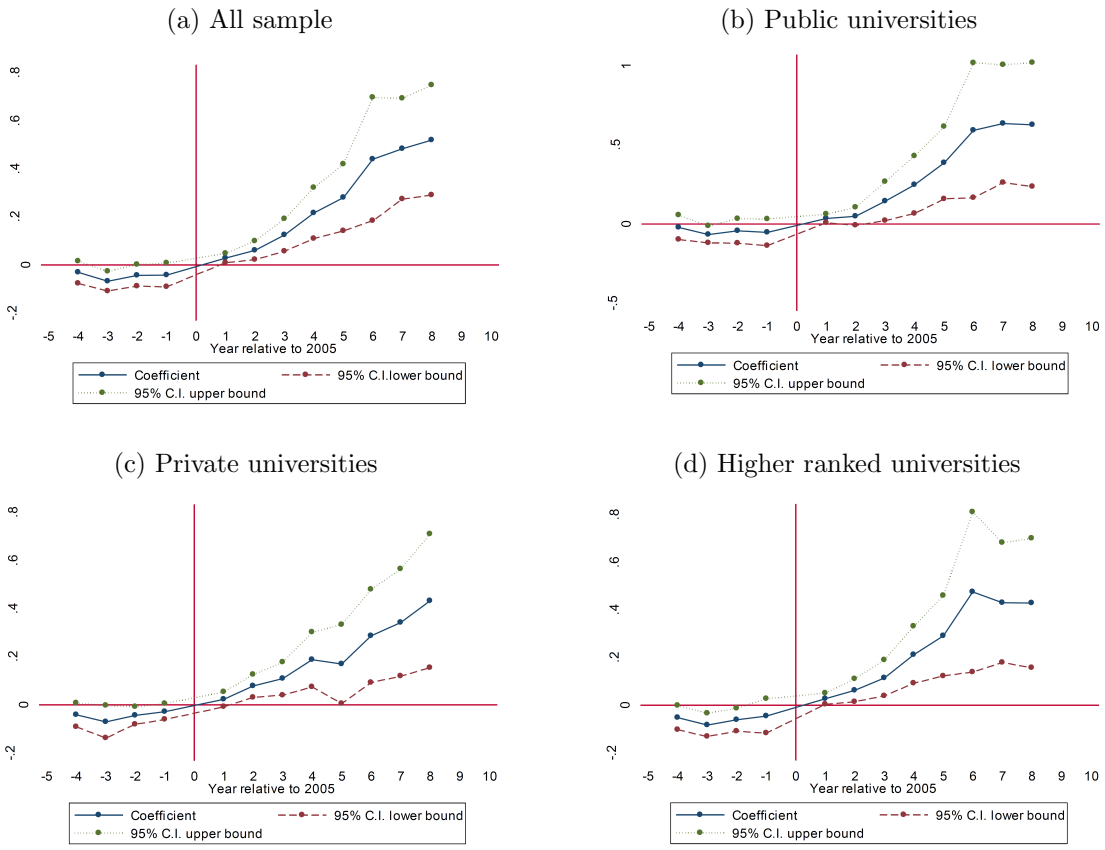
Notes: Data is collected from the Integrated Postsecondary Education Data System (IPEDS). Based on Carnegie Classification 2000, Research universities refer to Doctoral/Research universities (Extensive) and Doctoral/Research universities (Intensive). The fraction of foreign students is calculated by dividing the total number of nonresident aliens by the total number of students.

Figure 5: Average Number of Foreign Undergraduate Students at American Research Institutions



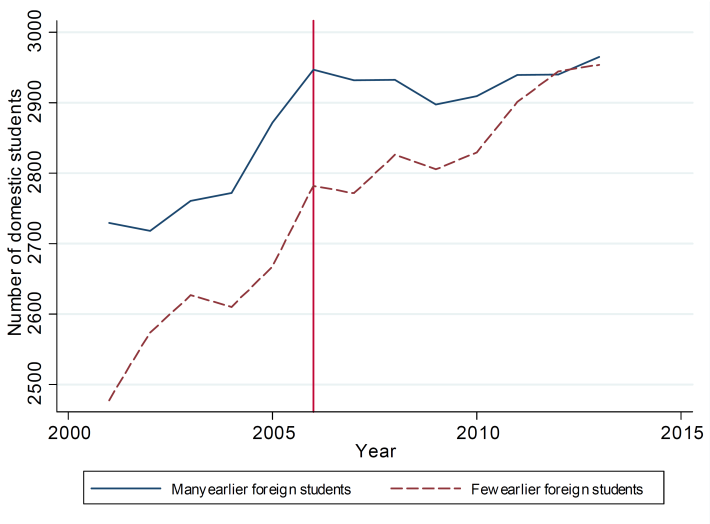
Notes: I split the sample into two groups. Institutions with many foreign students are schools that had more than the median number of full-time first-time foreign students between 1998 and 2000, and institutions with few foreign students are in the residual group.

Figure 6: First Stage Coefficients on Number of Foreign Undergraduate Students



*Notes:*The solid lines in each figure plot the baseline first-stage coefficients (α_k) by running Equation 2 using the number of full-time first-time foreign undergraduate students as the dependent variable for all universities, public universities, private universities and higher ranked universities, respectively. The dashed and dotted lines represent the 95% confidence intervals of the point estimates.

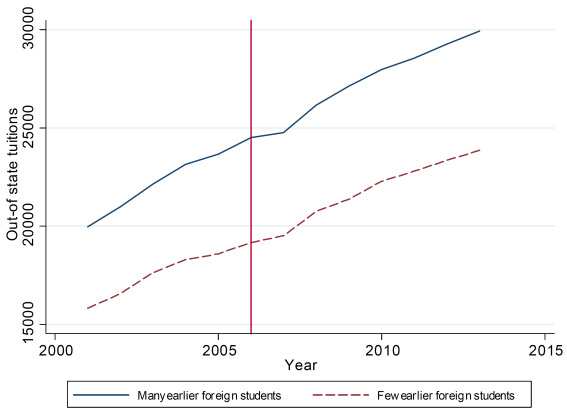
Figure 7: Average Number of Domestic Students in American Research Institutions (Higher Ranked)



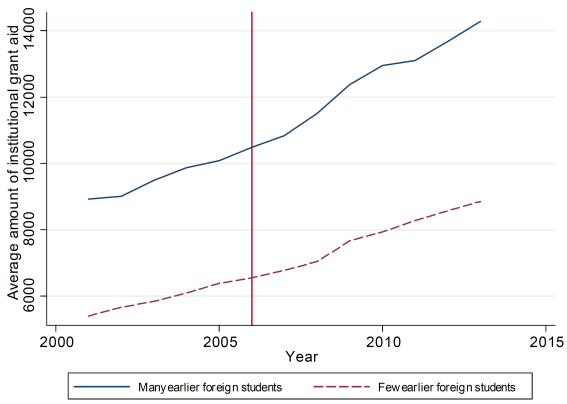
*Notes:*I split the sample into two groups. Institutions with many foreign students are schools that had more than the median number of full-time first-time foreign students between 1998 and 2000, and institutions with few foreign students are in the residual group. In this figure, I only include the institutions whose rankings are in the top 100.

Figure 8: Institutional Financial Outcomes, by Type of institutions, 2001-2013

(a) Non-discounted tuition



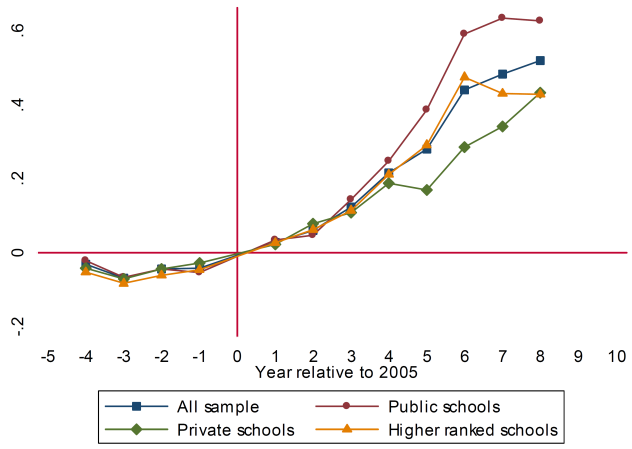
(b) Institutional grant aid



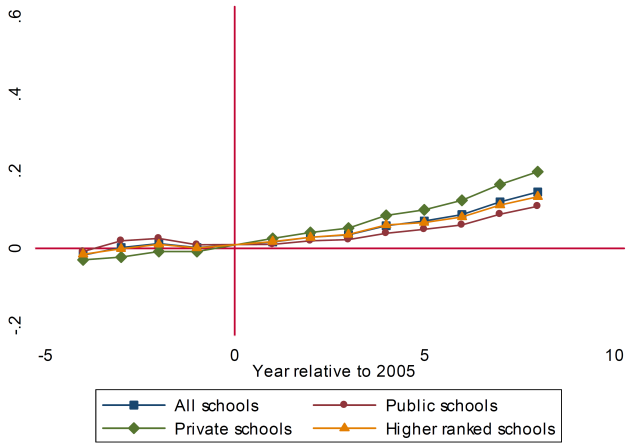
*Notes:*I split the sample into two groups. Institutions with many foreign students are schools that had more than the median number of full-time first-time foreign students between 1998 and 2000, and institutions with few foreign students are in the residual group. Non-discounted tuition consists of out-of-state tuition at public universities and tuition at private universities. Tuition and institutional grant aid are deflated by the Consumer Price Index. CPI adjustments such that 100=2013.

Figure 9: Robustness Check: Number of Graduate Students, 2001-2013

(a) Baseline first stage coefficients



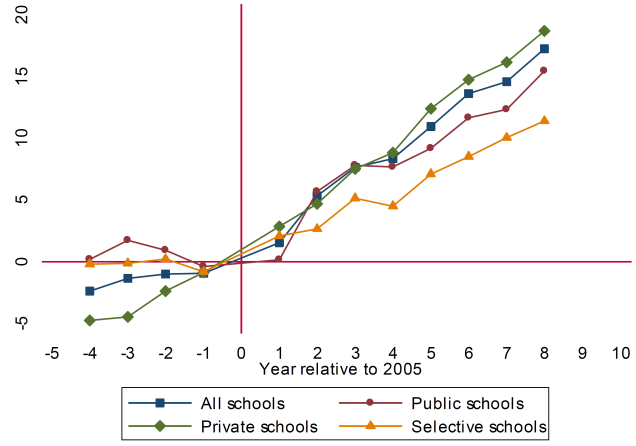
(b) Coefficients on number of graduate students



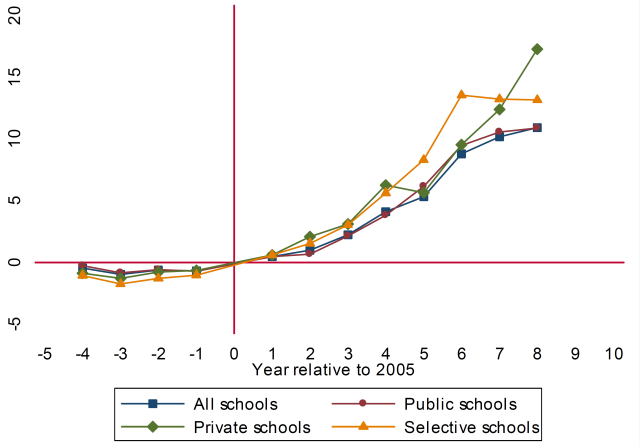
*Notes:*Figure (a) plots the coefficients (α_k) in Equation 2 using the number of full-time first-time foreign undergraduate students as the dependent variable. In other words, I combine all solid lines in Figure 8 in one graph. Figure (b) plots the coefficients (α_k) in Equation 2 using the number of full-time first-time foreign graduate students as the dependent variable.

Figure 10: Robustness Check: Number of Applications, 2001-2013

(a) Coefficients on Number of Applications



(b) Approximated Foreign Applications



*Notes:*Figure (a) plots the coefficients (α_k) in Equation 2 using the number of applications as the dependent variable. Figure (b) plots the baseline first-stage coefficients (Table 1) divided by the approximated foreign students' enrollment rate. The foreign students' enrollment rate is assumed to be 1/4 of the overall enrollment rate. The overall enrollment rate in a particular year equals the number of full-time first-time undergraduate students enrolled divided by the total number of applications.

Table 1: First Stage Results, 2001-2013

Dependent variable: the number of foreign undergraduates	*All Schools* (1)	*Public* (2)	*Private* (3)	*Higher Ranked* (4)	*Lower Ranked* (5)
$BeforeForeign * 2001$ *(t-4)*	-.031	-.022	-.042*	-.053**	.053
	(.023)	(.039)	(.025)	(.026)	(.035)
$BeforeForeign * 2002$ *(t-3)*	-.068***	-.066**	-.071**	-.083***	-.013
	(.021)	(.027)	(.034)	(.025)	(.037)
$BeforeForeign * 2003$ *(t-2)*	-.044*	-.044	-.044**	-.061***	.008
	(.023)	(.039)	(.018)	(.024)	(.050)
$BeforeForeign * 2004$ *(t-1)*	-.042*	-.053	-.028*	-.046	-.040
	(.025)	(.043)	(.017)	(.036)	(.027)
$BeforeForeign * 2005$ *(t)*	–	–	–	–	–
$BeforeForeign * 2006$*(t+1)*	.029***	.034***	.023	.027**	.007
	(.010)	(.014)	(.015)	(.012)	(.028)
$BeforeForeign * 2007$ *(t+2)*	.060***	.048*	.078***	.062***	.000
	(.020)	(.029)	(.024)	(.024)	(.036)
$BeforeForeign * 2008$ *(t+3)*	.124***	.144**	.109***	.115***	.032
	(.034)	(.062)	(.034)	(.038)	(.055)
$BeforeForeign * 2009$ *(t+4)*	.216***	.249***	.188***	.212***	.049
	(.054)	(.092)	(.057)	(.060)	(.090)
$BeforeForeign * 2010$ *(t+5)*	.281***	.387***	.170**	.292***	.027
	(.071)	(.116)	(.082)	(.085)	(.089)
$BeforeForeign * 2011$ *(t+6)*	.441***	.592***	.286***	.475***	.041
	(.130)	(.216)	(.097)	(.169)	(.115)
$BeforeForeign * 2012$ *(t+7)*	.484***	.635***	.342***	.431***	.230
	(.107)	(.189)	(.112)	(.127)	(.183)
$BeforeForeign * 2013$ *(t+8)*	.520***	.628***	.433***	.429***	.302
	(.116)	(.199)	(.140)	(.137)	(.224)
Cragg-Donald F statistics	49.75	35.07	32.62	14.42	10.25
Year fixed effects	Y	Y	Y	Y	Y
Institution fixed effects	Y	Y	Y	Y	Y
Number of universities	246	162	84	100	146
Number of observations	3,198	2,106	1,092	1,300	1,898

Note: Standard errors are reported in parentheses and are clustered at the institutional level. $BeforeForeign$ represents the historical number of full-time first-time foreign students at a particular university between 1998 and 2000. *** P<0.01 ** P<0.05 * P<0.1

Table 2: Effects on Domestic Student Enrollment

Dependent variable: the number of domestic undergraduates	*All Schools* (1)	*Public* (2)	*Private* (3)	*Higher Ranked* (4)
Number of foreign students	-.538	-.068	-.690	-1.290**
	(.475)	(.715)	(.598)	(.543)
Year fixed effects	Y	Y	Y	Y
Institution fixed effects	Y	Y	Y	Y
Number of universities	246	162	84	100
Number of observations	3,198	2,106	1,092	1,300

Note: Standard errors are reported in parentheses and are clustered at the institutional level. In column (4), based on 2015 U.S. News ranking, top-100 universities are classified as higher ranked universities. *** P<0.01 ** P<0.05 * P<0.1

Table 3: Heterogeneous Effects on Domestic Student Enrollment by Demand Constraints Levels

	All Schools		Higher ranked	
Dependent variable: the number of domestic undergraduates	*Stable enrollment*	*Fluctuating enrollment*	*Stable enrollment*	*Fluctuating enrollment*
	(1)	(2)	(3)	(4)
Number of foreign students	-1.348***	.803	-1.381***	.054
	(.443)	(.537)	(.436)	(.410)
Cragg-Donald Wald F statistics	29.73	46.14	12.28	25.85
Year fixed effects	Y	Y	Y	Y
Institution fixed effects	Y	Y	Y	Y
Number of universities	82	82	41	25
Number of observations	1,066	1,066	533	325

Note: Standard errors are reported in parentheses and are clustered at the institutional level."Stable enrollment" means the school's ten-year percentage change (between 1991 and 2000) in the total enrollment is smaller than the change at the lower tertile level, and "fluctuating enrollment" means the school's ten-year percentage change (between 1991 and 2000) in the total enrollment is greater than the change at the upper tertile level. In columns (3) and (4), I focus on top-100 universities only. *** P<0.01 ** P<0.05 * P<0.1

Table 4: Effects on SAT Scores

Dependent variable: SAT scores	*SAT 25th verbal*	*SAT 75th verbal*	*SAT 25th math*	*SAT 75th math*
	(1)	(2)	(3)	(4)
Number of foreign students	.036	.033*	.048**	.070***
	(.023)	(.020)	(.021)	(.019)
Cragg-Donald Wald F statistics	48.51	48.51	49.20	49.20
Year fixed effects	Y	Y	Y	Y
Institution fixed effects	Y	Y	Y	Y
Number of universities	234	234	234	234
Number of observations	2,762	2,762	2,780	2,780

Note: Standard errors are reported in parentheses and are clustered at the institutional level. From columns 1-4, I use the SAT 25th verbal percentile score, SAT 75th verbal percentile score, SAT 25th math percentile score and SAT 75th math percentile score as dependent variables, respectively *** P<0.01 ** P<0.05 * P<0.1

Table 5: Effects on Institutional Financial Outcomes

	Discounted tuition at public schools	*Non-discounted tuition*	*Discounted fees at public schools*	*Non-discounted fees*	*Institutional grant aid*	*Average salaries for instructional staff*
	(1)	(2)	(3)	(4)	(5)	(6)
Number of foreign students	3.927*	9.564***	.233	1.206	12.346**	10.274*
	(2.222)	(3.667)	(.953)	(1.255)	(5.644)	(5.651)
Cragg-Donald Wald F statistics	35.07	49.75	35.07	49.75	49.67	49.75
Year fixed effects	Y	Y	Y	Y	Y	Y
Institution fixed effects	Y	Y	Y	Y	Y	Y
Number of universities	162	246	162	246	246	246
Number of observations	2,106	3,198	2,106	3,198	3,195	3,198

Note: Standard errors are reported in parentheses and are clustered at the institutional level. Discounted tuition and fees are in-state tuition and fees at public universities. Non-discounted tuition and fees are out-of-state tuition and fees at public universities and tuition and fees at private universities. Tuition, fees, institutional grant aid and average salaries are dollars and are deflated by the Consumer Price Index (CPI). CPI adjustments such that 100=2013. *** P<0.01 ** P<0.05 * P<0.1

Table 6: Robustness Checks: Excluding Great Recession Observations

	Number of domestic students (higher ranked) (1)	*Non-discounted tuition* (2)	*Institutional grant aid* (3)
Number of foreign students	-1.317***	9.443***	11.999**
	(.536)	(3.599)	(5.443)
Cragg-Donald F statistics	15.19	54.07	53.96
Year fixed effects	Y	Y	Y
Institution fixed effects	Y	Y	Y
Number of universities	100	246	246
Number of observations	900	2,214	2,211

Notes: Standard errors are reported in parentheses and are clustered at the institutional level. I exclude observations in 2007-2010. Tuition and institutional grant aid are dollars and are deflated by the Consumer Price Index (CPI). CPI adjustments such that 100=2013. *** P<0.01 ** P<0.05 * P<0.1

Table 7: Robustness Checks: Excluding Ten Large Universities

	Number of domestic students (higher ranked) (1)	*Non-discounted tuition* (2)	*Institutional grant aid* (3)
Number of foreign students	-.515	13.533***	12.743***
	(.667)	(4.500)	(5.097)
Cragg-Donald F statistics	9.36	43.19	43.12
Year fixed effects	Y	Y	Y
Institution fixed effects	Y	Y	Y
Number of universities	91	236	236
Number of observations	1,183	3,068	3,065

Notes: Standard errors are reported in parentheses and are clustered at the institutional level. I exclude 10 universities that have the largest number of full-time first-time foreign students between 1998 and 2000. Tuition and institutional grant aid are dollars and are deflated by the Consumer Price Index (CPI). CPI adjustments such that 100=2013. *** P<0.01 ** P<0.05 * P<0.1

Table 8: Robustness Checks: Including Group/Institution-Specific Linear Time Trends

	Number of domestic students (1)	*Non-discounted tuition* (2)	*Institutional grant aid* (3)	*Number of domestic students* (4)	*Non-discounted tuition* (5)	*Institutional grant aid* (6)
Number of foreign students	-2.412***	10.799**	23.446**	-1.300***	16.757	5.323
	(.638)	(4.747)	(9.867)	(.132)	(23.704)	(4.098)
Cragg Donald F statistics	7.00	21.92	21.89	4.82	17.36	17.31
Year fixed effects	Y	Y	Y	Y	Y	Y
Institutional fixed effects	Y	Y	Y	Y	Y	Y
Group-specific linear time trends	Y	Y	Y	N	N	N
Institution-specific linear time trends	N	N	N	Y	Y	Y
Number of universities	100	246	246	100	246	246
Number of observations	1,300	3,198	3,195	1,300	3,198	3,195

Note: Standard errors are reported in parentheses and are clustered at the institutional level. Tuition and institutional grant aid are deflated by the Consumer Price Index (CPI). CPI adjustments such that 100=2013. In columns (1) to (3), I divide the sample into 22 groups based on their initial number of full-time first-time students between 1998 and 2000, with each group having 1000-student bands, and add group-specific linear time trends. In columns (4) to (6), I add institution-specific linear time trends. *** P<0.01 ** P<0.05 * P<0.1

Table 9: Heterogeneous Effects on Institutional Outcomes by Size of Schools

	Small-sized Schools			Large-sized Schools		
	Number of domestic students	*Non-discounted tuition*	*Institutional grant aid*	*Number of domestic students*	*Non-discounted tuition*	*Institutional grant aid*
	(1)	(2)	(3)	(4)	(5)	(6)
Number of foreign students	-.502	31.847**	46.117*	-1.061**	8.375**	6.933**
	(.594)	(15.090)	(25.523)	(.555)	(4.086)	(3.286)
Cragg Donald F statistics	11.71	11.71	11.66	20.98	20.98	20.98
Year fixed effects	Y	Y	Y	Y	Y	Y
Institutional fixed effects	Y	Y	Y	Y	Y	Y
Number of universities	82	82	82	82	82	82
Number of observations	1,066	1,066	1,066	1,066	1,066	1,066

Note: Standard errors are reported in parentheses and are clustered at the institutional level. Tuition and institutional grant aid are deflated by the Consumer Price Index (CPI). CPI adjustments such that 100=2013. Small-sized schools are those whose total number of full-time first-time undergraduate students between 1998 and 2000 are at the bottom tertile, while large-sized schools are those whose total number of full-time first-time undergraduate students between 1998 and 2000 are at the upper tertile. *** P<0.01 ** P<0.05 * P<0.1

Table 10: Robustness Checks: Placebo Tests, 2001-2005

	Number of foreign students (1)	*Number of domestic students (higher-ranked)* (2)	*Non-discounted tuition* (3)	*Institutional grant aid* (4)	*SAT 25th math* (5)	*SAT 75th math* (6)
*BeforeForeign*2001*	.013	.014	-1.736**	-.742	-.016	.006
	(.014)	(.244)	(.799)	(.894)	(.010)	(.009)
*BeforeForeign*2002*	-.024	.026	-.482	-.851	-.001	.004
	(.019)	(.276)	(.414)	(.911)	(.011)	(.007)
*BeforeForeign*2004*	.002	.241	.923	-.152	-.004	.009
	(.020)	(.153)	(.553)	(.622)	(.011)	(.008)
*BeforeForeign*2005*	.044*	.355	1.841**	-.216	-.006	.003
	(.025)	(.178)	(.858)	(.613)	(.011)	(.007)
Year fixed effects	Y	Y	Y	Y	Y	Y
Institution fixed effects	Y	Y	Y	Y	Y	Y
Number of universities	246	100	246	246	221	221
Number of observations	1,230	500	1,230	1,227	996	996

Notes: Standard errors are reported in parentheses and are clustered at the institutional level. I only include prior shock period observations. I run Equation 2 moving the shock year from 2006 to 2003. *** P<0.01 ** P<0.05 * P<0.1

Table 11: Other Specifications: A Triple-Difference Design

	Number of foreign students (1)	*Number of domestic students* (2)	*Number of foreign students (higher ranked)* (3)	*Number of domestic students (higher ranked)* (4)
$BeforeForeign * Post2002 * Major$*(t-2)*	-.002		-.001	
	(.009)		(.011)	
$BeforeForeign * Post2004 * Major$*(t-1)*	-.001		-.000	
	(.010)		(.013)	
$BeforeForeign * Post2006 * Major$(t)	–		–	
$BeforeForeign * Post2008 * Major$*(t+1)*	.016**		.015	
	(.008)		(.010)	
$BeforeForeign * Post2010 * Major$*(t+2)*	.043***		.047***	
	(.009)		(.011)	
$BeforeForeign * Post2012 * Major$*(t+3)*	.066***		.062***	
	(.012)		(.015)	
Cragg-Donald F statistic	32.30		7.79	
Number of foreign students		-.441		-.786*
		(.381)		(.466)
Number of universities	237	237	100	100
Number of observations	6,892	6,892	2,330	2,330

Notes: Standard errors are reported in parentheses and are clustered at the institutional-year level. *Major* equals one if students are enrolled in business, engineering, mathematics or physical science. *Shock* equals one if the year is equal to or after 2006. *** P<0.01 ** P<0.05 * P<0.1

Table 12: Other Specifications: Using *PostYear* as a Single Indicator Variable

	Number of domestic students (higher ranked)	*Non-discounted tuition*	*Institutional grant aid*
	(1)	(2)	(3)
Number of foreign students	-1.348**	13.259***	14.785**
	(.626)	(4.803)	(6.648)
F statistics	13.46	18.83	18.83
Year fixed effects	Y	Y	Y
Institution fixed effects	Y	Y	Y
Number of universities	100	246	246
Number of observations	1,300	3,198	3,195

Notes: Standard errors are reported in parentheses and are clustered at the institutional level. Tuition and institutional grant aid are dollars and are deflated by the Consumer Price Index (CPI). CPI adjustments such that 100=2013. *** P<0.01 ** P<0.05 * P<0.1

Table 13: Other Specifications: Ignoring Time Series Information

	Number of domestic students (higher ranked)	*Non-discounted tuition*	*Institutional grant aid*
	(1)	(2)	(3)
Number of foreign students	-1.348**	13.259***	14.822**
	(.626)	(4.803)	(6.651)
F statistics	7.29	10.17	10.17
Year fixed effects	Y	Y	Y
Institution fixed effects	Y	Y	Y
Number of universities	100	246	246
Number of observations	200	492	492

Notes: Standard errors are reported in parentheses and are clustered at the institutional level. Tuition and institutional grant aid are dollars and are deflated by the Consumer Price Index (CPI). CPI adjustments such that 100=2013. *** P<0.01 ** P<0.05 * P<0.1

Table 14: Other Specifications: An Alternative IV Strategy (I)

	Number of domestic students (higher ranked) (1)	*Non-discounted tuition* (2)	*Institutional grant aid* (3)
Number of foreign students	-1.456***	9.703***	13.035**
	(.592)	(3.730)	(5.789)
F statistics	10.56	17.97	17.97
Year fixed effects	Y	Y	Y
Institution fixed effects	Y	Y	Y
Number of universities	100	246	246
Number of observations	1,300	3,198	3,195

Notes: Standard errors are reported in parentheses and are clustered at the institutional level. Tuition and institutional grant aid are dollars and are deflated by the Consumer Price Index (CPI). CPI adjustments such that 100=2013. *** P<0.01 ** P<0.05 * P<0.1

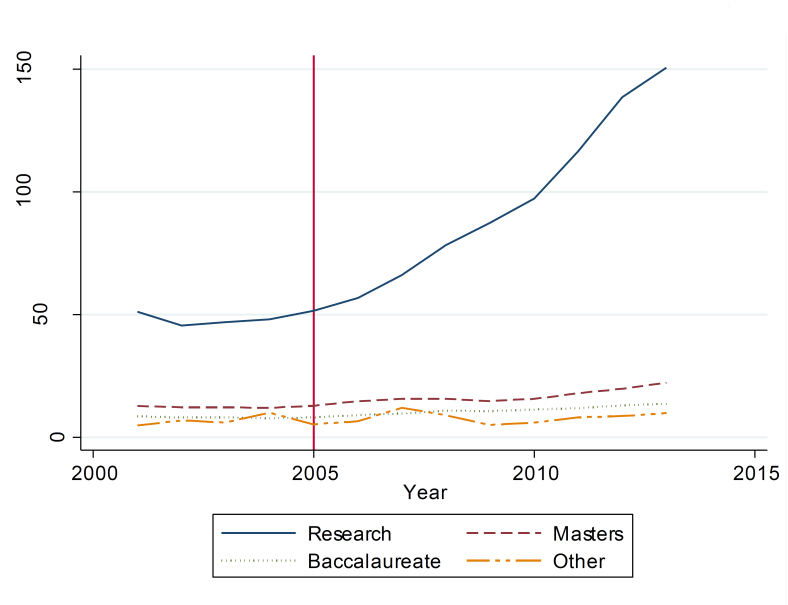
Table 15: Other Specifications: An Alternative IV Strategy (II)

	Fraction of domestic students (higher ranked) (1)	*Non-discounted tuition* (2)	*Institutional grant aid* (3)
Fraction of foreign students	-1.028***	792.07**	1639.15***
	(.366)	(329.16)	(493.53)
First-stage coefficient	0.013***	0.009***	0.009***
	(.005)	(.003)	(.003)
Year fixed effects	Y	Y	Y
Institution fixed effects	Y	Y	Y
Number of universities	100	246	246
Number of observations	1,300	3,198	3,195

Notes: Standard errors are reported in parentheses and are clustered at the institutional level. Tuition and institutional grant aid are dollars and are deflated by the Consumer Price Index (CPI). CPI adjustments such that 100=2013. *** P<0.01 ** P<0.05 * P<0.1

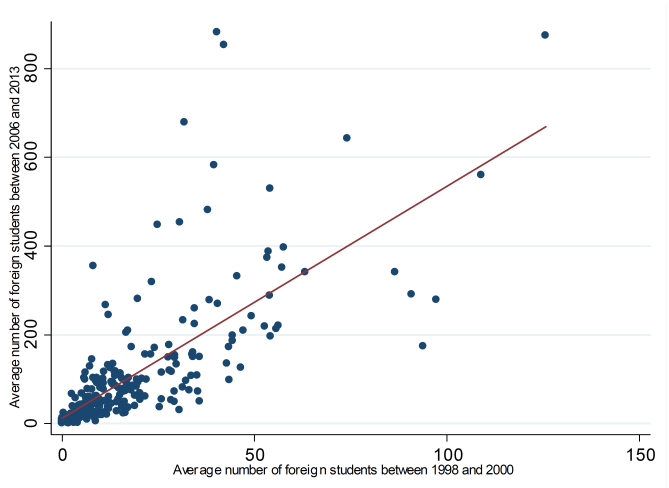
9 Appendix Figures and Tables

Figure A.1: Number of Full-time First-time Foreign Undergraduate Students, by Type of Schools



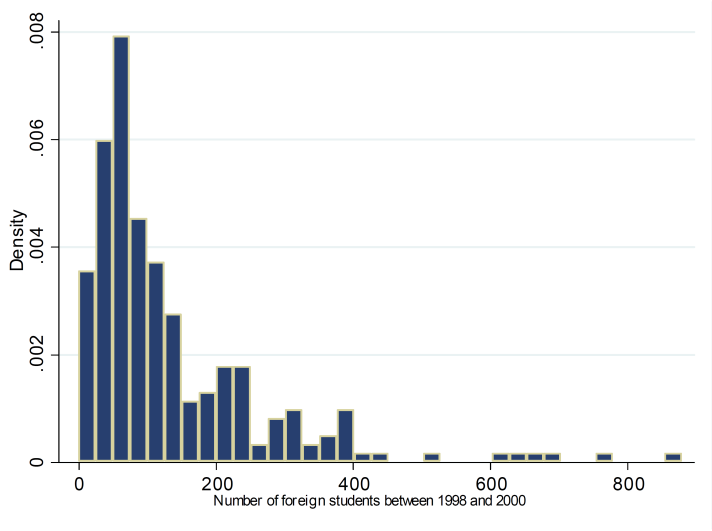
Notes: Data is collected from the Integrated Postsecondary Education Data System (IPEDS).

Figure A.2: Number of Full-time First-time Foreign Undergraduate Students Before and After the Shock



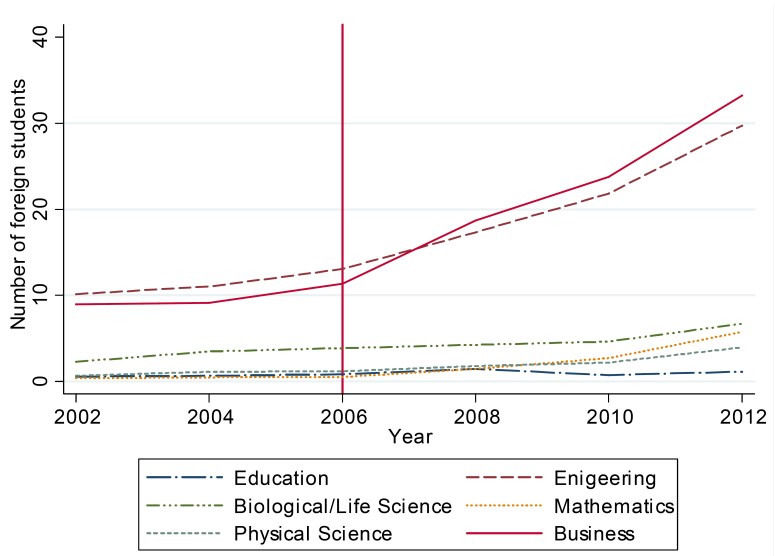
Notes: Data is collected from the Integrated Postsecondary Education Data System (IPEDS). Based on Carnegie Classification 2000, research universities refer to Doctoral/Research universities (Extensive) and Doctoral/Research universities (Intensive).

Figure A.3: The Distribution of the Number of Foreign Undergraduate Students Between 1998 and 2000



Notes: Data is collected from the Integrated Postsecondary Education Data System (IPEDS). Based on Carnegie Classification 2000, research universities refer to Doctoral/Research universities (Extensive) and Doctoral/Research universities (Intensive).

Figure A.4: Number of Foreign Undergraduate Students by Major, 2002-2012



Notes: Data is collected from the Integrated Postsecondary Education Data System (IPEDS). I only focus on American research universities.

Table A.1: Main Variable Descriptions

Variable Name	Variable Description	Dataset Source
efalevel	Level of students (=24 Full-time students, Undergraduate, Degree/certificate-seeking, First-time)	IPEDS
eftotlt	Grand total men and women enrolled for credit during the fall	IPEDS
efnralt	Nonresident aliens enrolled for credit during the fall	IPEDS
tuition2	In-state average tuition for full-time undergraduates students	IPEDS
tuition3	Out-of-state average tuition for full-time undergraduate students	IPEDS
fee2	In-state required fees for full-time undergraduate students	IPEDS
fee3	Out-of-state required fees for full-time undergraduates students	IPEDS
saltotl	Average salary equated to 9 months of full-time instructional staff-all ranks	IPEDS
igrnt_a	Average amount of institutional grant aid received by full-time first-time undergraduate students	IPEDS
f2d03	State appropriations at non-profit private institutions	IPEDS
f1b11	State appropriations at public institutions	IPEDS

Table A.2: Summary Statistics

	Overall	*2001-2005*	*2006-2013*
	(1)	(2)	(3)
Grand total (full-time first-time)	2546.76	2381.18	2650.25
	(1681.77)	(1583.01)	(1733.03)
Nonresident alien total (full-time first-time)	79.65	48.69	99.01
	(121.18)	(52.83)	(145.42)
Discounted tuition/fees:			
In-state tuition in public schools	5908.05	4649.40	6694.70
	(2998.84)	(2564.96)	(2982.93)
In-state fees in public schools	1676.98	1600.73	1724.64
	(1786.13)	(1767.92)	(1796.44)
Non-Discounted tuition/fees:			
Out-of state tuition in public schools	22708.12	19754.99	24553.82
& tuition in private schools	(9919.18)	(8648.20)	(10213.87)
Out-of state fees in public schools	1571.46	1459.07	1641.70
& fees in private schools	(2182.56)	(2046.26)	(2261.25)
Average amount of institutional grant aid	9210.50	7735.17	10130.34
	(8012.70)	(6475.62)	(8712.75)
Average salaries for full-time instructional staff	89982.37	89072.48	90551.05
	(18792.12)	(17999.67)	(19253.54)

Note: The sample only consists of research institutions. Based on Carnegie Classification 2000, research universities refer to Doctoral/Research universities (Extensive) and Doctoral/Research universities (Intensive). Both discounted tuition and non-discounted tuition are sticker prices. Discounted tuition/fees are in-state tuition/fees charged by public schools for state residents, while non-discounted tuition/fees are out-of-state tuition/fees charged by public schools for out-of-state students and tuition/fees charged by private schools. Tuition, fees, institutional grant aid and average salaries are dollars and are deflated by the Consumer Price Index (CPI). CPI adjustments such that 100=2013. Tuition and fees are for full-time undergraduate students, average institutional grant aid are for full-time first-time undergraduate students, and average salaries for full-time instructional staff is equated to 9 months.

Table A.3: List of Schools by the Initial Number of Foreign Undergraduate Students

Top 30		Bottom 30	
School Name	#	School Name	#
Purdue University-Main Campus	880	Texas A&M University-Commerce	0
Boston University	763	Clark Atlanta University	0
University of Michigan-Ann Arbor	681	Widener University-Main Campus	0
The University of Texas at El Paso	657	SUNY College of Enviromental Science and Foresty	0
University of Pennsylvania	636	Union Institute & University	0
Cornell University	606	Ball State University	1
New York University	519	Yeshiva University	3
Northeastern University	443	University of La Verne	6
University of Wisconsin-Madison	404	University of Northern Colorado	8
University of South California	401	Wilmington University	8
University of Virginia-Main Campus	394	New Mexico Institute of Mining and Technology	10
Carnegie Mellon University	390	University of Southern Mississippi	11
Rutgers University-New Brunswick	380	South Carolina State University	12
Indiana University-Bloomington	379	Texas Woman's University	17
The University of Texas at Austin	378	Catholic University of America	17
Ohio State University-Main Campus	376	University of St. Thomas	18
Arizona State University-Tempe	374	University of Dayton	18
The New School	369	Colorado State University-Fort Collins	20
University of Arizona	345	University of South Dakota	20
University of Miami	330	National Louis University	22
Georgetown University	326	Clemson University	23
Derexl University	319	University of Colorado Denver	25
Harvard University	311	South Dakota State University	26
Columbia University	311	University of Mississippi	27
Florida International University	305	Oakland University	27
Brown University	304	University of Rhode Island	27
Johns Hopkins University	300	Missouri University of Science and Technology	28
Michigan State University	295	Jackson State University	29
University of Oregon	284	Texas A&M University-Kingsville	30
University of Illinois at Urbana-Champaign	282	University of Missouri-St. Louis	30

Note: # means the number of full-time first-time foreign undergraduate students between 1998 and 2000

Table A.4: Heterogeneous Effects on Domestic Student Enrollment by Demand Constraints Levels

	All Schools		Higher ranked	
Dependent variable: the number of domestic undergraduates	*Stable enrollment*	*Fluctuating enrollment*	*Stable enrollment*	*Fluctuating enrollment*
	(1)	(2)	(3)	(4)
Number of foreign students	-1.728***	.615	-1.265***	.016
	(.447)	(.560)	(.478)	(.555)
Cragg-Donald Wald F statistics	18.84	38.74	9.88	14.84
Year fixed effects	Y	Y	Y	Y
Institution fixed effects	Y	Y	Y	Y
Number of universities	82	82	51	20
Number of observations	1,066	1,066	663	260

Note: Standard errors are reported in parentheses and are clustered at the institutional level. "Stable enrollment" means the coefficient of variation of undergraduate enrollment(between 1991 and 2000) is at the lower tertile level, and "fluctuating enrollment" means the coefficient of variation of undergraduate enrollment(between 1991 and 2000) is greater than the change at the upper tertile level. In columns (3) and (4), I focus on top-100 universities only. *** P<0.01 ** P<0.05 * P<0.1

Table A.5: Robustness Checks: Including Group/Institution-Specific Quadratic Time Trends

	Number of domestic students	*Non-discounted tuition*	*Institutional grant aid*	*Number of domestic students*	*Non-discounted tuition*	*Institutional grant aid*
	(1)	(2)	(3)	(4)	(5)	(6)
Number of foreign students	-2.605***	11.333**	28.242***	-1.465**	7.987***	4.900
	(.829)	(4.762)	(9.174)	(.726)	(2.040)	(4.283)
Cragg Donald F statistics	7.00	21.90	21.87	4.82	17.31	17.26
Year fixed effects	Y	Y	Y	Y	Y	Y
Institutional fixed effects	Y	Y	Y	Y	Y	Y
Group-specific quadratic trends	Y	Y	Y	N	N	N
Institution-specific quadratic trends	N	N	N	Y	Y	Y
Number of universities	100	246	246	100	246	246
Number of observations	1,300	3,198	3,195	1,300	3,198	3,195

Note: Standard errors are reported in parentheses and are clustered at the institutional level. Tuition and institutional grant aid are deflated by the Consumer Price Index (CPI). CPI adjustments such that 100=2013. In columns (1) to (3), I divide the sample into 22 groups based on their initial number of full-time first-time students between 1998 and 2000, with each group having 1000-student bands, and add group-specific quadratic time trends. In columns (4) to (6), I add institution-specific quadratic time trends. *** P<0.01 ** P<0.05 * P<0.1

Table A.6: Undergraduate Enrollment Rate by Overall Students and International Students

(a) University of California-Santa Cruz

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Overall	13.04%	13.6%	15.17%	14.27%	11.8%	11.86%	12.8%	11.57%	8.56%	9.93%
International	5.5%	4.89%	6.8%	3.14%	0.55%	0.96%	0.70%	0.94%	3.82%	3.04%

Notes: Enrollment Rate = Admit Rate* Yield Rate.
(http://planning.ucsc.edu/irps/ugAdmissions/froshAdmits(2005-2015).pdf)

(b) University of California-Los Angeles

	2002	2003	2004	2005	2006	2007	2008	2009
Overall	9.79%	9.48%	8.61%	10.47%	10.16%	8.99%	8.54%	8.02%
International	4.3%	4.96%	7.81%	6.36%	9.4%	5.9%	5.09%	3.78%

Notes: Enrollment Rate = Admit Rate* Yield Rate.
(http://www.admissions.ucla.edu/Prospect/Adm_fr/Frosh_Prof.htmf)

(c) Other Available Information

	UC-Berkeley (2014)	Pennsylvania Stete (2014)	Gergetown University (2011)
Overall	7.82%	24.14	8.28%
International	4.99%	11.84	5.22%

Notes: http://internationaloffice.berkeley.edu/students/current/enrollment_data;
http://admissions.psu.edu/apply/statistics/;
https://uadmissions.georgetown.edu/firstyear/studentprofile