The Impact of International Students on U.S. Graduate Education -

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Abstract -
1-in-7 graduate students in the U.S. is a resident of a foreign country, however, little is known about the impacts foreign students have on the education of U.S. natives. This paper assesses whether international students affect native enrollment at the graduate level. I focus on a large boom in foreign enrollment that began in 1995 and was concentrated in graduate programs at Research universities. Heightened scrutiny over international students in the aftermath of the 9/11 terrorist attacks delayed visa processing, putting a sudden stop to these tremendous inflows of graduate students from abroad. I separately estimate the impact of foreign graduate students on the enrollment of native graduate students over the boom (1995-2001) and bust (2002-2005) using a panel of 292 U.S. Research universities. I leverage growth in the college age population (18-30) in sending countries, for the boom, and national declines in student visa issuance due to post-9/11 policies, for the bust, to form an exogenous supply-driven instrument for actual flows of graduate students from abroad. Results show foreign students crowd-in natives 1-for-1 during both the boom and bust periods. These effects appear strong for natives in STEM programs. Exploration of various mechanisms suggests peer effects and complementarity with faculty may allow for the expansion in the supply of graduate education. -

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I. Introduction

Over the last half-century U.S. graduate education has sustained a remarkable internationalization. Non-U.S. citizens on temporary student visas (commonly referred to as international or foreign students) grew from 130,000 in 1970 to 720,000 in 2010, even outpacing immigration which grew four-fold over this period. Currently, 15% of graduate students and 1-in-3 Science & Engineering (S&E) Masters or Ph.D. recipients hail from overseas (NSF 2013). The large presence of foreign nationals in graduate programs is no accident—the strength of U.S. higher education and an unusually “open door” policy towards students has attracted growing numbers of applicants from overseas. Curiously, little is understood about how this internationalization has affected U.S. graduate education, and in particular, the outcomes of U.S.-native-born (native) students.

This paper examines whether international students impact the enrollment of natives in graduate school. If the supply of available seats in graduate schools is fixed, inflows of students from abroad may crowd out natives. Increased competition in admissions or in classrooms may result in the displacement of native students. Alternatively, if the number of seats in graduate programs is elastically supplied, native enrollment may not decline. Native enrollment may even increase if international students expand university resources through increased tuition revenue, or lead to additional faculty, perhaps through complementarities in the production of research or undergraduate education. Additionally, the higher presence of foreign students may increase native demand for graduate education—beneficial foreign peer effects or increased collaborative opportunities for research may also increase native enrollment.

Graduate education supplies the advanced skills necessary for innovation and technological advances, which in turn spur economic growth (e.g. Romer 1990; Jones 1995). The effect of international students on natives is of particular relevance to the supply of skills as immigration policy does not accommodate individuals who wish to remain in the U.S. after completing their studies. If foreign students decrease native enrollment (crowd-out), this would likely decrease the supply of advanced skills in the labor force and lead to lower levels of innovation. Alternatively, if foreign nationals bolster opportunities for natives in graduate schools (crowd-in), the larger supply of advanced skills would stimulate research and development.

Related research has found that highly educated immigrants tend to concentrate in Scientists, Engineers, Technology professionals, and Mathematicians (STEM) occupations, and that foreign STEM workers have had both competitive and complementary effects on the labor market outcomes of natives (e.g. Kerr & Lincoln 2010; Borjas & Doran 2012, 2013; Moser et al. 2013; Peri et al. 2014). Foreign graduate students, who also concentrate in STEM fields, may similarly impart externalities on their native peers. Thus, this research expands the scope of studies on the labor market impact of immigration by assessing native outcomes in higher education.

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1 Foreign students have also outpaced immigrants in terms of their “presence”. The share of immigrants in the U.S. population grew 3 fold, from 4.7% in 1970 to 13% in 2010, while the share of foreign students in total post-secondary enrollment increased by a factor of 5. These figures on foreign students and immigrants are taken from IIE (2013) and the U.S. Census (2013), respectively.

2 The graduate level refers to Masters, Professional, and Doctoral degree programs.

3 Census estimates show that one-fourth of all U.S. STEM workers have a graduate degree.

4 While there are no caps on the number of foreign students, there are strictly regulated caps on nearly all other groups of foreign nationals, making it very difficult for international students to secure work in the U.S. The main channel for foreign graduates of U.S. universities to find work in the U.S. is to secure an H-1B visa. However, the H-1B visa program is tightly controlled with a cap of 65,000.
Finally, recently renewed efforts at immigration reform have generated intense policy debate over international students. Industry leaders argue that large skill shortages necessitate increased pathways for international students to secure U.S. jobs, while others counter that U.S. native workers would suffer. Curiously, however, few ask whether foreign students affect natives, even though U.S. student visa policy has no numerical limits, and increased foreign competition in graduate programs might directly create labor market skill shortages. This research evaluates the costs and benefits of increasing foreign enrollment, and thereby informs U.S. student visa policy.

Existing research has linked international graduate students with university-level outcomes such as patenting and academic research in STEM departments (Chellaraj et al. 2008; Maskus et al. 2012). Previous research on whether international students impact native enrollment in graduate school is sparse. Bound, Turner, & Walsh (2009) examine the large inflow of Chinese students into U.S. Physics Ph.D. programs after the renormalization of relations with China in 1979. They provide descriptive evidence against crowding-out effects—the number of native Physics Ph.D. recipients actually grew over the 1980s.

Borjas (2007) analyzes whether foreign students crowd natives out of graduate education using panel fixed effects regressions on university-level enrollments from over 1,100 institutions from the Institutional Post-secondary Education Data System (IPEDS). While negative associations between foreign and White native enrollment are suggestive of crowding out, positive correlations are estimated for native Asians, Blacks, and Hispanics. Regets (2007) implements an identical panel regression specifications on data from the Survey of Graduate Students and Postdoctorates in Science and Engineering (SGSPE) from 1982-1995. Quite differently, foreign enrollments in S&E programs are positively correlated with native White enrollment, and negatively correlated with enrollment of native Asians.

Using data on doctoral degrees conferred by field of study from the Survey of Earned Doctorates (SED) from 1966-2002, Zhang (2009) adopts a similar panel approach that leverages within-field instead of within-university variation. Within Science and Engineering (S&E) disciplines, the number of doctoral degrees awarded to foreign students positively relates to the number awarded to natives. In contrast, non-S&E fields show a negative correlated between foreign and native doctoral degree conferred. These findings suggest differential impacts by field of study.

Different sample periods, alternative data sources, distinct sources of variation, and measurement discrepancies (e.g. enrollments vs. doctoral degrees) make reconciling the inconsistent findings across these studies difficult. Importantly, endogeneity bias is a main concern that underlies all of these studies. The regression based studies (Borjas 2007; Regets 2007; and Zhang 2009) use panel fixed effects models that effectively remove bias from time-invariant university- or field-specific factors, and also national time trends. Nonetheless, confounding factors that vary within universities (or fields) over time are problematic. Increases in the quality of a university, for example, would bias estimates upward if both natives and foreign students are drawn to better programs.

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5 Thus, they are able to remove the influence of fixed factors specific to universities (or fields), and national trends that may simultaneously be correlated with the number of foreign students and native outcomes.
I extend the existing research in several important ways. Primarily, I address endogeneity bias by focusing on a quasi-experimental boom and bust cycle in foreign graduate enrollment over the 1995-2005 decade. From 1995-2002 U.S. Research I and II (Research) universities experienced nearly 50% growth in graduate enrollment from abroad—a tremendous figure, considering the 8% growth that occurred from 1990-1995. The terrorist attacks on September 11th, 2001, and especially the discovery that several hijackers had exploited student visas, effectively interrupted the boom in students from abroad. Increased caseloads and design flaws in new foreign student policies led to delays in student visa issuance. Foreign graduate enrollment declined from 2002 to 2005. As these issues began to clear up by 2006, graduate enrollment from abroad again began to increase (Freeman 2010).

To correct for endogeneity bias, I construct instrumental variables from aggregate supply-shifters that helped fuel the boom and bust cycle, but were unrelated to enrollment of native graduate students. Specifically, the interaction of university-level lagged international enrollments by sending nation in 1993 with growth in the college age (18-30) population by sending nation forms exogenous, supply-driven predictions of foreign graduate enrollment over the boom period. Similarly, using aggregate declines in all student visa holders after 2001 forms predictions of international graduate enrollments over the bust that are driven by complications arising from the rollout of new foreign student policies, and hence exogenous to native outcomes. These supply-driven predictions are used as instruments to distill exogenous variation in actual foreign enrollment, and identify impacts on native enrollment.

In addition to addressing endogeneity bias through instrumental variables, I also adopt a more demanding panel-fixed effects specification that accounts not only for time-invariant university factors, but also for university-specific characteristics that change linearly over time. Also different from prior literature, I explore two distinct sources of variation—I separately estimate the effect of increases in foreign enrollment over the boom, and decreases in foreign enrollment over the bust. Lastly, I provide a novel exploration of various mechanisms, including foreign competition or peer effects that may alter native demand for graduate education, and complementarities with faculty in research production that may lead to shifts in the supply of graduate education.

My analysis finds that foreign graduate students are positively associated with native enrollment. Estimates suggest that an additional/fewer foreign student leads to one additional/fewer native. As nearly 50% of foreign graduate students study STEM fields, I find crowd-in effects to be concentrated in native STEM enrollment. Further these effects appear to be concentrated in Public universities. The finding that estimated effects on natives increase with their likelihood of interaction with foreign students, suggest positive peer effects may spur native demand. Additionally, growth in foreign students is associated with increases in faculty, thereby expanding the supply of graduate education. This may arise from complementarities with faculty in research production.

The next section provides a brief summary of international students in U.S. graduate education and their evolution over the boom and bust period to provide a richer context to the period of analysis. Section III then describes the basic methodology and the data used. Section IV describes the basic construction of the key instrumental variables. Section V presents the main results. Section VI discusses the validity of the instrumental variables approach. Section VII examines whether peer effects that stimulate native demand, or growth in faculty that -
II. International Graduate Students and the Boom and Bust of 1995-2005

Over recent decades U.S. graduate programs have experienced rising international enrollment (Figure 1A). The decade between 1995 and 2005 was particularly volatile—a rapid boom in students from abroad lasted until 2002, after which foreign graduate enrollments began to decline until 2005. During this boom and bust cycle the percentage of foreign graduate students climbed nearly 3 percentage points from 1995-2002 and then fell by more than 1 percentage point from 2002-2005 (Figure 1B).

Curiously, this boom and bust in international graduate students was not felt equally across all swaths of higher education. Figure 2 plots foreign enrollment from 1995-2005 by academic level (graduate and undergraduate) and by university type (Baccalaureate, Masters, or Research). Baccalaureate and Masters institutions saw little fluctuation in foreign enrollment. Interestingly, it was Research universities that sustained the majority of the boom and bust in foreign graduate students. Remarkably, from 1995-2005 foreign undergraduate enrollment at Research Universities exhibited almost no change. The concentrated nature of the boom and bust in graduate programs of Research Universities, and the lack of changes to international enrollment in other sectors of higher education facilitate the study of the impact of foreign graduate students on natives. Additionally, the historical circumstances that surrounded the boom and bust of 1995-2005 further bolster the analysis of this quasi-experimental period.

By the mid-1990s there was much uncertainty over the ability of U.S. universities to remain the world leaders in hosting international students. Stagnant international enrollment in the early 1990s, combined with investigations into the foreign student visa program after the 1993 World Trade Center bombing generated concern that the global allure of American Universities was in decline. Few signs hinted at the surge in international graduate students at Research Universities that was to come.

Unexpectedly, Research Universities began to see graduate enrollments from abroad grow after 1995 and accelerate through the turn of the millennium. By 2002 foreign graduate enrollment had grown by over 45% from its 1995 level. Several factors may have contributed to

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6 Though the declines in international enrollments after 2002 were not as large or as fast as increases during the boom (1995-2002), I nevertheless refer to the 2002-2005 period as a bust for simplicity. The 2002-2005 period may also be characterized as a break in trend.

7 For lack of better term, I characterize the small and short-lived fall in international enrollment from 2002-2005 as a “bust”, even though it appears to be more of a break in trend.

8 I use the 2000 Carnegie Classification to categorize institutions as Baccalaureate, Masters, or Research. “Bachelors” institutions include those labeled in the 2000 Carnegie Classification as Baccalaureate Colleges—Liberal Arts, Baccalaureate Colleges—General, or Baccalaureate/Associate’s Colleges. “Masters” institutions comprise Master’s Colleges and Universities I and II. Research universities include Doctoral/Research Universities—Extensive and Doctoral/Research Universities—Intensive. These labels refer to the main focus of the college/university, and are assigned based on the number of Bachelors, Masters, and Doctoral degrees awarded by the institution. For more details on the Carnegie Classification, see http://classifications.carnegiefoundation.org/downloads/2000_edition_data_printable.pdf.

9 One reason why the post-2006 period increases in foreign graduate students (see Figure 1A) were not analyzed was because undergraduate enrollments from abroad also surged. Additionally, focusing on the post-2006 period would incur complications due to the Great Recession.

10 Investigations revealed that Eyad Ismoil, one of the terrorists in the 1993 bombing, had overstayed his student visa and should have been deported. A New York Times article, “Fewer Foreigners Choosing U.S. Colleges” on November 23rd, 1995 expressed that declining international enrollments and increased competition from universities in other nations were of great concern for higher education administrators. See http://www.nytimes.com/1995/11/24/us/fewer-foreigners-are-choosing-us-colleges.html.
this boom. For example, many countries saw expansions in income over the late-1990s, possibly allowing more individuals to afford study abroad. Interestingly, the U.S. experienced two other boom and bust cycles that occurred over the same period. Figure 3 compares the boom and bust in foreign graduate enrollment (Figure 3A) with the expansion and contraction of H-1B visa policy (Figure 3B), and the Dot Com boom and bust (Figure 3C).\textsuperscript{11}

While such economic phenomena may have encouraged this sudden acceleration in foreign enrollment, slow changing demographic shifts in sending nations helped sustain the large inflows from abroad. In particular, expansions in the population of tertiary education age (18-30) in sending countries also pushed students abroad, and importantly, were plausibly exogenous to the educational outcomes of U.S. native graduate students. My empirical strategy exploits college age population growth in sending countries to develop an exogenous, supply-push instrument for actual increases in foreign enrollment.

The boom in international graduate students was suddenly interrupted after the September 11\textsuperscript{th}, 2001 terrorist attacks. After discovering several terrorists had exploited student visas, policy makers scrambled to identify and close loopholes in the student visa program.\textsuperscript{12} In the aftermath of 9/11, several policies were implemented that had a strong impact on international student entry. The passage of the USA Patriot Act in October of 2001 and the Enhanced Border Security and Visa Reform Act in May of 2002 slowed foreign student entry in two broad manners. First, these legislations broadened the sharing of educational records by Federal agencies for security purposes. This contributed to rising caseloads and processing times to check student visa petitions for potential fraud (GAO 2005).\textsuperscript{13}

Second, the passage of these acts generated funding and hard deadlines for the implementation of a comprehensive internet-based student tracking system entitled the Student Exchange and Visitors Information Service (SEVIS)—by January 1st, 2003 all universities hosting international students had to use SEVIS to update all information on their foreign students. The initial rollout of SEVIS, however, created severe complications for university administrators—technical glitches in software and complex new regulations associated with SEVIS led to severe delays in student visa processing (Alberts 2007).\textsuperscript{14}

The combination of increased investigative caseloads for student visa petitions and the bungled implementation of SEVIS interrupted the boom in foreign graduate enrollment. Interestingly, in the first year after 9/11 international graduate enrollments continued to grow (between 2001 and 2002), even though student visa issuances saw a large drop.\textsuperscript{15} After 2002,\textsuperscript{16}

\textsuperscript{11} In the late 1990s Congress temporarily raised the cap on H-1B visas and then returned the cap to its original level in 2004, leading to a rise and subsequent fall in the number of highly skilled foreign professionals working in the U.S. Similarly, the Dot Com boom and bust was characterized by a large bubble in the equity values of U.S. internet-based companies that burst in 2000.

\textsuperscript{12} Notoriously, two 9/11 hijackers obtained a student visa but never actually showed up to classes. Loopholes in the student visa program were so severe that in March 2002, the INS sent student visa approval notices for two of the 9/11 hijackers to a flight school which to they had applied. For more reading see Wasem (2002) or the September 27th, 2001 New York Times article, “Suspects in Hijackings Exploited Loopholes in Immigration Policy”.

\textsuperscript{13} For example, by October of 2003 the average processing time for petitions that fell under Visa Mantis, a security clearance program for students and scholars working with sensitive technologies had grown to over 80 days.

\textsuperscript{14} Of the problems the rollout of SEVIS created includes an instance where documents from one University printed out at a different University. See a May 20th, 2993 GCN article “Student tracking falters in its early rollout”.

\textsuperscript{15} Appendix Figure A1 displays visa issuances for all classes of student visas (F-1, J-1, M-1). Note that foreign students may enter on any of these visas, J-1 (cultural exchange) visas are also awarded to non-students (e.g. scholars). Importantly, visa issuance data represents inflows while enrollment figures (e.g. Figure 1A, 2, and 3A) represent stocks. Interestingly, Figure A1 shows a large drop in visas issued from 2001-2002, while Figure 3A shows that foreign graduate enrollment grew from 2001-2002. This may be due to several factors, for example: (1) the declines in student visa issuances reflect applied to non-graduate students, or (2) new graduate student enrollment declined in 2002 which but attrition/completion rates fell even further. Unfortunately, no data on graduate...
graduate enrollment from abroad first stagnated and then began to decline. The bust in foreign graduate students was transitory—issues with SEVIS and visa processing delays were cleared up by 2005, after which graduate enrollment from abroad continued its upward march.16

My empirical strategy leverages these post-9/11 policies to develop an exogenous instrument for declines in international graduate enrollment during the bust. These policies had a profound effect on reducing international enrollment, yet were plausibly unrelated to the educational outcomes of natives. Before describing the instrumental variables in greater detail, two additional features of international graduate students over the boom and bust cycle help provide a richer context to the analysis. -

Figure 4 plots the share of international students across five fields of study from 1997-2005. More than half of all graduate students from abroad were enrolled for study in STEM disciplines.17 Because this share was relatively constant over the period, the boom and bust in international enrollment were likely felt more strongly by STEM departments. The next largest fields of study were social science and business, followed by Arts & Humanities. Lastly, in the aggregate there were not substantial changes in the composition international students in terms of their distribution across fields of study.

A second interesting feature regarding the composition of international students pertains to their countries of origin. While the U.S. hosts international students from nearly every nation in the world, the majority of foreign students over this period came from only a few countries. Figure 5 reveals that 40-50% of all foreign graduate students came from Asia. Furthermore, China and India were the main contributors with each contributing on average around 20% of total international enrollment. The next largest group included students from Europe and the Americas, followed by the Middle East and Africa.

Importantly, the boom and bust in graduate enrollment was not specific to any single country. Figure 6 plots standardized enrollment trends18 from 1995-2006 by region (Asia, Europe, Americas, Middle East, and Africa), and also for the two largest sending countries—China and India. During the boom, graduate enrollment from all regions grew by around 3 standard deviations of their foreign enrollment from 1995-2005. Although enrollment from predominantly Muslim nations declined immediately after 9/11, by 2002 the heightened security policies and the glitches in SEVIS began to take their toll on students from across the world.

In sum, the data reveal an unusual boom and bust cycle over the 1995-2005 decade. Nearly half of the international students over this period tended towards STEM disciplines, and a majority were from Asian countries—China and India in particular. Further, the boom and bust manifested in enrollments from all countries/regions of origin, and was not unique to any one single sending region or nation. The historical context surrounding the 1995-2005 decade provides descriptive evidence of the important role that foreign college age population growth and 9/11 security policies had in generating the boom and bust cycle. These plausibly exogenous factors, combined with the concentrated nature of the boom and bust at Research universities -

\[\text{students by level (new vs. existing) is available. Therefore the foreign graduate student growth from 2001-2002 is dropped from the analysis of the boom period.}\]

\[\text{16 GAO (2005) shows that Visa Mantis processing times had dramatically fallen to around 15 days by 2005. -}\]

\[\text{17 STEM disciplines include Computer and Information Sciences, Mathematics, Engineering, Physical Sciences, Life Sciences, Health Professions, Agriculture and Natural Resources, and Architecture & Environmental Design.}\]

\[\text{18 Enrollments have been standardized within-countries. Specifically, enrollment figures for each country-year are standardized by the mean and standard deviation of enrollments for that country over the entire 1995-2006 period. -}\]
provide a quasi-experiment to analyze whether foreign graduate students crowd out natives. Before continuing to further analysis, however, the next section describes the methodology and data.

### III. Methodology & Data

I adopt the following empirical specification to measure the impact of foreign graduate students on native enrollment:

\[
\frac{\Delta N_{ut}}{E_{ut}} = \alpha + \beta \frac{\Delta F_{ut}}{E_{ut}} + \gamma_u + \gamma_t + \varepsilon_{ut} \tag{1}
\]

The analysis in this paper uses specification 2 to estimate the impact of international students, separately for the boom and bust. The dependent variable in 2 represents a standardized measure of native enrollment flows, calculated as the yearly change in native graduate enrollment \((\Delta N_{ut} = N_{ut+1} - N_{ut})\) divided by initial total graduate enrollment \((E_{ut})\). The key independent variable represents standardized foreign enrollment flows, measured as the yearly change in foreign graduate enrollment \((\Delta F_{ut} = F_{ut+1} - F_{ut})\), also standardized by initial total graduate enrollment. The variables \(\gamma_u\) and \(\gamma_t\) represent university- and period-fixed effects, respectively, and \(\varepsilon_{ut}\) is a zero-mean error term.

Data on native and foreign students by university come from the Integrated Post-Secondary Education Data System (IPEDS). IPEDS contains data from a series of surveys of U.S. higher education institutions conducted by the Department of Education’s National Center for Education Statistics. International and native enrollment counts by university are taken from the 1995-2005 Fall Enrollment surveys. IPEDS asks universities to distinguish students as either residents or non-residents. Specifically, a non-resident is any “person who is not a citizen or national of the United States and who is in this country on a visa or temporary basis and does not have the right to remain indefinitely.” Residents include native-born students and immigrants who have been admitted legally with the purpose of obtaining permanent residency. I use this demarcation to identify international students (non-residents) from U.S. natives and permanent residents (residents).

As figure 2 revealed the boom and bust cycle was mostly concentrated in Research-focus Universities. I assemble a list of 300 U.S. universities defined as Research-focus by the Carnegie Classification. Of these, 292, are consistently identified in IPEDS from 1995-2005. In addition to comprising the main group of institutions affected by the international graduate...

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19 For simplicity I refer to these standardized enrollment flows simply as “flows” or “enrollment flows.”
20 Post-secondary institutions receiving federal funds under title IV are mandated to complete IPEDS surveys.
21 Counts generally reflect enrollment at the beginning of each academic year. Universities report fall enrollment as of their official reporting dates or by October 15th. Universities that do not operate on a traditional academic year calendar, report fall enrollment anytime between August 1st and October 31st. For more details see https://surveys.nces.ed.gov/IPEDS/Downloads/Forms/package_6_74.pdf.
22 U.S.-born natives cannot be separated from immigrants that have become U.S. citizens.
23 The Carnegie classification is a categorization of colleges and universities based on cutoffs in the number different degrees awarded, as measured from the IPEDS surveys of a reference year. Continual revisions of the classification are performed every few years, using more recent IPEDS data. Therefore, universities near the cutoffs and those that failed to respond to certain survey items in a reference year, tend to drop in and out of the “Research” classification. I obtain a time-consistent group of Research universities that represent the core of U.S. graduate education, by selecting those institutions that are ever classified as a Research school in any of 1994, 2000, 2005, or 2010 Carnegie classifications.
student boom and bust, the 292 Research universities represent the core of graduate education in the U.S. They account for 60% of all graduate enrollment, 80% of foreign graduate enrollment, and award a majority of all 1st professional and master's degrees. Furthermore, these schools represent the bulk of U.S. doctoral education, as they award 90% of Ph.D. degrees. Further summary statistics on these 292 Research universities are available in Table 1.

I estimate whether foreign graduate students crowd out natives over the boom and bust on the sample of 292 Research universities. Although increases in foreign enrollment persisted until 2002 (see Figure 3A), I define the boom as from 1995-2001.24 As stated earlier, declines in student visa issuance in 2002 create uncertainty as to why graduate enrollment continued to increase. Additionally, even though SEVIS was fully implemented in early 2003, testing of SEVIS began at 12 Boston area institutions in November 2001 (Wasem 2002). The analysis of the bust period covers 2002-2005.

IV. Instrumental Variables Strategy

Because OLS estimates of \( \beta \) may still suffer from endogeneity bias, I develop instrumental variables based on forces that altered the supply of foreign graduate students over the boom and bust cycle, but were exogenous to native enrollment. The IVs propagate these supply-side forces across Research universities with varying intensity, based on each university’s historical (1993) stocks of foreign graduate students.25 Schools with large prior foreign student populations likely felt the effects of these factors more intensely due to well-developed networks.

College age population growth in sending nations helped generate supply-push increases in international enrollment during the boom.26 As the college age population expanded, the number of individuals seeking graduate education and the number of individuals applying to and enrolling in U.S. graduate programs also grew. Native enrollment was likely unrelated to these demographic shifts to young populations abroad. I develop an instrument based on these demographic shifts by interacting the country-of-origin distribution of foreign graduate students across universities in 1993 with subsequent college age population growth of that country through the boom years. These interactions predict how enrollment from each sending nation would have evolved had it increased at exactly the rate of that nation’s college age population.

For the bust period I leverage the supply-restricting influence of post-9/11 policies to develop an instrument for declines in international enrollment. I do so by interacting the college population-imputed nationality-of-origin distribution of international graduate students across universities in 2001 with subsequent aggregate declines in the population of student visa holders by nationality group. These interactions predict how enrollment from each sending nationality would have evolved had it grown at exactly the rate of the college age population over the boom and then fell at the rate of declines in student visa holders.

\[ 24 \text{ Results including 2002 in the boom period are generally very similar and available upon request.} \]

\[ 25 \text{ Similar IV approaches have been used to study a variety of topics, and are also commonly found in research on the impact of immigration on native labor market outcomes (e.g. Card, 2001; Kerr & Lincoln, 2010; Peri, Shih, & Sparber 2014).} \]

\[ 26 \text{ College age population growth has long been recognized as a strong determinant of international student flows to the U.S. (e.g. McMahon 1992; Bird & Turner 2014; Shih 2014).} \]
Summing these predictions within-universities and across all foreign nationalities forms a supply-driven measure of foreign enrollment over the boom and bust. Taking changes in these predicted measures and standardizing by total enrollment forms instruments for actual enrollment flows. To avoid encumbering the discussion, I leave out a technical discussion of the instruments. A longer version of this paper with a detailed description of their construction is available from the author upon request.

V. The Impact of International Students on Natives

V. A. Main Results

To assess whether international students crowd out natives from graduate education, I estimate two-stage least-squares (2SLS) regressions of specification 2, separately for the boom and bust. The college age population-based IV is used to instrument actual foreign enrollment flows over the boom, while the IV based on post-9/11 policies that created student visa declines is used as an instrument for foreign enrollment flows during the bust.

Table 2 presents 2SLS results for native enrollment flows. Panel A and B show results for the boom and bust periods, respectively. Each panel presents 2SLS estimates of $\beta$ from equation 2. Column (1) presents 2SLS results from the main specification 2, weighted by total graduate enrollment. Column (2) reruns the regressions in column (1) without outliers, defined as universities that report international flows below the 1st percentile or above the 99th percentile of all foreign graduate flows over the 1995-2005 decade. Column (3) presents OLS estimates.

The first-stage F-statistics on the excluded instruments, from Table 2, are reprinted for reference. Notice the F-statistics in both the boom and bust are all above the recommended level of 10 to avoid weak instruments. Thus, the instruments have sufficient first-stage power.

Column (1) under panel A of Table 2 presents the main 2SLS estimates for the boom. The point estimate (1.59) is statistically significant at the 5% level and indicates that foreign students crowd-in natives. Column (2) examines whether measurement error in the form of outliers affect the results. For the boom period, while the power of the instrument increases dramatically, the 2SLS estimate remains stable (1.30).

Because the dependent and independent variables are standardized by the same factor, these point estimates can be interpreted in terms of actual bodies. The main estimate in column (1) suggests that 10 additional foreign graduate students increase native enrollment by almost

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27 Constructing this instrument requires very detailed data on historical foreign graduate enrollment by country of origin at each university. To this end, I have obtained restricted-access data from the Institute of International Education (IIE) that provides graduate enrollment by country of origin by universities in 1993. The IIE has collected data on international students for over 50 years. They conduct annual censuses of international students in the U.S. by surveying colleges and universities. Specifically, I use data from the International Student Census surveys which IIE uses to publish its annual Open Doors reports. 1993 is the earliest year of data available from the IIE on international graduate enrollment by country of origin by university. Additionally, it is the only year available prior to 1995.

28 All regressions are weighted by total enrollment to mitigate the loss in precision due to heteroskedasticity. Standard errors are clustered at the university level to account for serial correlation in enrollment flows within universities.

29 2SLS results for specifications that remove universities whose data in IPEDS was imputed, or whose 1993 IIE enrollments by country of origin were imputed are nearly identical to the main specification in column (1). Thus, to reduce clutter I do not report these results in Table 3.
16. A formal Wald test, however, does not indicate the point estimate to be significantly different from 1.

Panel B of Table 2 displays results for the bust. The main estimates in column (1) also show a positive point estimate of 0.80, suggestive of crowd-in. However the estimates are statistically indistinguishable from zero. Interestingly, the results from column (2) show measurement error in the form of outliers is important to recognize. The point estimate from column (1) doubles when outliers are removed. Estimates from column (2) also find that international graduate students positively and significantly impact native enrollment. Interpreted literally, the bust estimate from column (2) suggests that every 10 foreign graduate students that left during the bust led to a loss of 16 natives.

Note that OLS estimates in column (3) are smaller than the 2SLS estimates in columns (1) and (2). This pattern is evident in both the boom and bust, and is consistent with presence of unobserved shocks to native enrollment that also negatively correlate with international student flows. For example, universities attempting to offset declines in state appropriations may do so by increasing enrollment of foreign students, who often pay full sticker price tuition. The downward biased OLS estimates do not support the notion of unobserved shocks, such as increased school quality, that lead to both increases in both native and foreign enrollment.

V. B. Effects by Field of Study: STEM vs. Non-STEM

As shown in section II, over 50% of all foreign graduate students were enrolled in STEM departments (see Figure 4). Thus, the boom and bust cycle in foreign graduate students was highly concentrated in STEM departments. The high proclivity of international graduate students to study STEM fields suggests that the effects may be more pronounced on natives in STEM disciplines.

To examine differences in native enrollment by field of study I modify the dependent variable in specification 2, with native STEM or non-STEM enrollment flows, standardized by total graduate enrollment. Limited data from IPEDs only provides enrollments for 5 STEM fields (Biological sciences, Physical sciences, Math, Engineering, and Health Sciences) and 3 non-STEM fields (Education, Business, and Law). The main independent variable is the standardized yearly flow of foreign graduate students, and the instruments are the population-based IV and the 9/11-based IV for the boom and bust, respectively.

Results (in Table 3) show that effects are strong in STEM disciplines over the boom. Though results for non-STEM fields are not significant, recall that the only non-STEM fields available are Education, Business, and Law. Thus, further data is necessary to evaluate the impact on other non-STEM fields such as Sociology, Economics, and History.

The instrumental variable analysis reveals that international students do not crowd-out natives from graduate school, but rather crowd-in natives. These effects are evident in both the boom and bust periods, and for the boom appear to be strong for natives in STEM fields. Intuitively these results suggest that the supply of graduate education is able to expand quite elastically in response to increased enrollment of foreign students. Before exploring the
mechanisms through which these effects may occur, the next section discusses the assumptions necessary for valid IV inference.

VI. Instrument Validity & Robustness -

In addition to having sufficient first stage power, the validity of the earlier findings hinge crucially on whether the instruments also satisfy the exclusion restriction. The exclusion restriction requires that the instruments must only predict actual changes in international enrollment for the boom and bust, and cannot be correlated with any other factors that also affect the graduate education of U.S. natives. Since the IVs are constructed from the interaction of two separate variables—the nationality distribution of foreign graduate enrollment in 1993, and the nationality-specific growth factors (college age population for the boom, and declines in student visas for the bust)—it is necessary that each of these pieces must not be correlated with other factors that also affect native graduate enrollment flows within universities. While it is infeasible to rule out correlations with all other potential factors, I examine some issues of first order concern. 30.

In particular I check whether the instruments are correlated with undergraduate flows from abroad and find the instrument only has predictive power of foreign graduate flows. Additionally I develop controls for other U.S.-wide phenomenon that happened over the 1995-2005 decade including a rise and fall in H-1B visa issuances and also the Dot Com boom and bust. Results are robust to accounting for these factors. Various other checks show the results are not driven by the largest universities, by the foreign students from particular nationalities, or by imputations in IPEDS data. -

VII. Mechanisms

VII. A. Peer Effects -

Many studies have shown that high ability individuals often generate positive effects that spillover to their peers, and therefore peer effects from foreign students may increase native demand. 31 While the evidence is still limited, several studies support the notion that foreign graduate students in the U.S. are on average of very high quality. Gauß & Piacentini (2013) show that Chinese Ph.D. students in Chemistry perform as NSF doctoral fellowship recipients. Black & Stephan (2010) examine a sample of publications in Science with less than 10 coauthors and find that over 50% had a foreign student or postdoc as a coauthor. Further they find that around 60% of all graduate student coauthors are foreign.

To measure peer effects I exploit the fact that natives vary widely in terms of what they study. This is especially true when looking across races/gender groups. Asian and White males are much more heavily concentrated in STEM fields than Black and Latino women, for example. I develop an index of similarity based on how close the distribution of each native group across fields of study is to that of foreign students. Lower number values of this index, based on a chi-squared goodness-of-fit test, indicate more similarity to foreign students. -

30 Additionally, since the IV regressions are just-identified (i.e. there is one instrument for the endogenous independent variable in each period), no direct test of the exclusion restriction exists.
31 E.g. Mas & Moretti (2009); Carrell, Fullerton, & West (2009). -
I rerun 2SLS regressions for each native group and plot standardized coefficients against the index of similarity in figure 7. Panel A shows the effects for the boom period, and plots the standardized effect on native enrollment for a 1 standard deviation increase in foreign students. Panel B displays the results for the bust and shows the standardized effect on native enrollment for a 1 standard deviation decrease in foreign students. -

A clear pattern emerges during both the boom and bust periods. The impact on natives grows with their similarity to international students. During the boom, the effect of a 1 standard deviation increase in international students raised the enrollment of the most similar group (Asian men) by roughly $\frac{1}{2}$ of a standard deviation. In contrast the most dissimilar group (minority women) saw no effect from increased foreign enrollment. Over the bust a similar pattern appears—a 1 standard deviation decrease in foreign enrollment is associated with larger declines in native enrollment for more similar groups. While many of the point estimates are imprecisely estimated, the overall pattern suggests that the estimated crowd-in effects may be partly due to peer effects that attract natives whom are most likely to interact with foreign students. -

VII. B. Complementarity with Faculty -

If the number of seats in graduate programs is fixed, then increases in foreign students should crowd out natives. Crowd-in of natives would only be observed, then, if foreign students also induce expansions in the supply of graduate education. In particular prior research suggests that foreign graduate students, especially those in STEM fields, strongly complement faculty in research production. This section checks whether foreign graduate students expand the number of faculty, thereby alleviating supply constraints and allowing for increased native enrollment. -

To check this channel, I rerun main specification 2, replacing the dependent variable with the yearly change in faculty divided by total graduate enrollment in the initial year (i.e. the dependent variable is $\frac{\Delta \text{faculty}_{UT}}{E_{ut}}$, where $T$ indicates whether the faculty are tenure-track or instructional). Standardizing in this fashion allows the estimates to be directly interpreted in terms of the number of additional faculty associated with an increase in foreign enrollment. -

The results of this exercise are shown in Table 4. Columns (1) and (2) report results for tenure-track and instructional faculty, respectively, for the boom. Results show an extra 10 international students is associated with approximately 3 additional tenure-track faculty, and 1-2 instructional faculty. These results are statistically significant at the 10% level. Interestingly, the same positive relationship is not found for the bust period. Decreases in international enrollment did not lead to declines in faculty. The temporary nature of the bust may have and downward rigidity in faculty may attribute to the lack of findings during the bust.

VII. C. Other Channels -
Because international students often pay full sticker-price tuition, they may cross-subsidize the cost of educating natives, who often are offered discounted tuition. In response to exogenous increases in foreign students, universities may also raise sticker-price tuition revenues. Analysis of these two channels show that international students have little impact on revenues or resources per student or on in-state or out-of-state tuition. At the graduate level, it is likely that international students may be able to secure funding which would limit the cross-subsidization of natives. Additionally, rigidities in tuition price likely make raising and lowering tuition as a response to exogenous changes in international enrollment difficult in the short-run.

VIII. Conclusion

For decades, international students have maintained a large and growing presence in U.S. graduate education. While U.S. immigration policy places no numerical constraints on the number of international students that may study in the states, little is known regarding how this open door policy has affected higher education. In particular, little is known about the impact foreign students have on their native peers.

This paper examines whether foreign students crowd out natives from enrolling in graduate school. I analyze an unusual boom and bust in foreign graduate enrollment that took place at Research universities over the 1995-2005 decade. I mitigate endogenous factors by developing an instrument based exogenous, supply-push factors that contributed to the boom (1995-2001) and bust (2002-2005). In particular, growth in the college age (18-30) population in sending countries helped sustain the tremendous growth in foreign graduate enrollment over the boom, but were exogenous to native graduate education. Flaws in the implementation of post-9/11 security policies targeted towards foreign students interrupted the boom, and led to declines in foreign graduate enrollment that lasted until 2005. Interacting the nationality distribution of foreign graduate students across Research universities in 1993 with growth in the college age population by nationality, and declines in student visas due to post-9/11 policies, forms instruments for the boom and bust, respectively.

Results show that foreign students do not crowd-out, and actually crowd-in native students. Point estimates suggest that native enrollment increases one-for-one with foreign graduate enrollment. Similarly, over the bust a decline in one foreign graduate student is associated with a loss of one native graduate student. Nearly 50% of foreign graduate students study STEM fields, and I find the crowd-in effects to be strong in STEM fields. The crowd-in students may result from peer effects that increase native demand or through increases in the number of seats due to increases in faculty, possibly due to complementarities in research production.

Concerns over deteriorating educational quality, combined with unprecedented recent inflows of foreign students from China, raise the importance of understanding how foreign students affect U.S. higher education. Further research more closely examining how natives respond to foreign students, and analyzing other native outcomes such as degree completion and switching across fields of study would clarify how international students affect the education of natives in higher education.

32 This is especially true at public universities that have out-of-state tuition, the price for international students, and much cheaper in-state or in-district tuition.
References -


Bird, K., & Turner, S. (2013) "College in the States: Foreign Student Demand and Higher Education Supply in the U.S." unpublished working paper. -


Borjas, G. J. (2007). "Do Foreign Students Crowd Out Native Students from Graduate Program", In: Ronald G. Ehrenberg & Paula E. Stephan (Eds.). Science and the University, University of Wisconsin Press, pp. 134-149. -


Figure 1: Trends in International Graduate Students in the U.S., 1990-2013

A: International Enrollment

B: Percent International

Note: Series constructed from IPEDS Fall Enrollment Surveys, 1990-2013. Figures above include total enrollment of non-resident aliens at the graduate and professional levels, in Baccalaureate, Masters, and Research/Doctoral Universities as defined by the 2000 Carnegie Classification. Data reflects enrollment for the Fall of the corresponding year.
Figure 2: International Trends by Academic Level and University Type, 1995-2005 -

Note: Series constructed from IPEDS Fall Enrollment Surveys, 1990-2013. Figures above include total enrollment of non-resident aliens at the graduate and professional levels, in Baccalaureate, Masters, and Research/Doctoral Universities as defined by the 2000 Carnegie Classification.
Figure 3: International Graduate Student Boom and Bust, Research Universities, 1995-2005

A: Foreign Graduate Enrollment at Research Universities

B: H-1B Visas Issued and Cap

C: Nasdaq Index Closing Price, 2nd Quarter Daily Average

Note: Data on foreign enrollment from IPEDS fall enrollment surveys. Fall enrollment figures reflect the number of international students enrolled in the fall of the corresponding year. Data on H-1B visas issued are from the Department of State’s Non-immigrant Visa Statistics, available here: [http://travel.state.gov/content/visas/english/law-and-policy/statistics/non-immigrant-visas.html](http://travel.state.gov/content/visas/english/law-and-policy/statistics/non-immigrant-visas.html). For more detail about the H-1B visa program and the changes in the cap see Peri, Shih, & Sparber (2014). Data on Nasdaq Index stock prices are from Yahoo Finance Historical Prices. Figures reflect the average of the daily closing price of the Nasdaq Composite Index (IXIC) over the 2nd quarter of each year. The 2nd quarter averages are used since international students generally make enrollment decisions during this period.
Figure 4: International Graduate Students by Field of Study, 1997-2005

![Chart showing share of total international graduate students by field of study from 1997 to 2005, with categories including Arts & Humanities, Business, Other, Social Science, and STEM.]

Note: Data is from IIE’s Open Doors reports 1995-2005.

Figure 5: International Graduate Students by Region-of-Origin, 1995-2005

![Chart showing share of total international graduate students by region of origin from 1995 to 2005, with categories including Americas, Europe, Asia, China, India, Middle East, and Africa.]

Note: Data is from IIE’s Open Doors reports 1995-2005.
Figure 6: Boom and Bust by Country/Region-of-Origin, 1995-2006

Note: Data is from IIE Open Door Reports 1995-2006. Enrollments have been standardized within-countries. That is, enrollment figures for each country-year are standardized by the mean and standard deviation of enrollments for that country over the entire 1995-2006 period. Enrollment from China and India are also included in the enrollment counts for Asia, but are also plotted separately since they are the top sending countries.
Figure 7: Test for Peer Effects: 2SLS Effect vs. Index of Similarity

A: Boom, Effect of 1 sd inflow of international students

B: Bust, Effect of 1sd outflow of international students
### Table 1: Baseline (1995) Summary Statistics of Baccalaureate and higher Institutions

<table>
<thead>
<tr>
<th>Academic Level</th>
<th>Non-Research</th>
<th>Research</th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Dev.</td>
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<tr>
<td><strong>Undergraduate Enrollment</strong></td>
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</tr>
<tr>
<td>Total</td>
<td>1570</td>
<td>2617</td>
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<tr>
<td>International</td>
<td>4%</td>
<td>9%</td>
</tr>
<tr>
<td>U.S. Native/Perm. Resident</td>
<td>94%</td>
<td>13%</td>
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<tr>
<td><strong>Graduate Enrollment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>340</td>
<td>688</td>
</tr>
<tr>
<td>International</td>
<td>6%</td>
<td>12%</td>
</tr>
<tr>
<td>U.S. Native/Perm. Resident</td>
<td>90%</td>
<td>19%</td>
</tr>
<tr>
<td>White</td>
<td>73%</td>
<td>26%</td>
</tr>
<tr>
<td>Asian</td>
<td>4%</td>
<td>10%</td>
</tr>
<tr>
<td>Minority</td>
<td>12%</td>
<td>19%</td>
</tr>
<tr>
<td><strong>1st Professional Degrees</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
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<td>54</td>
</tr>
<tr>
<td>International</td>
<td>5%</td>
<td>13%</td>
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<tr>
<td>U.S. Native/Perm. Resident</td>
<td>93%</td>
<td>16%</td>
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<tr>
<td><strong>Masters Degrees</strong></td>
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</tr>
<tr>
<td>Total</td>
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<td>International</td>
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<td>U.S. Native/Perm. Resident</td>
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<td><strong>Ph.D. Degrees</strong></td>
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</tr>
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<td>Total</td>
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<td>International</td>
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<td>22%</td>
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<td>U.S. Native/Perm. Resident</td>
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<td>27%</td>
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<td><strong># of Universities</strong></td>
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<tr>
<td><strong>Type of University</strong></td>
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</tr>
<tr>
<td>Public</td>
<td>18%</td>
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<tr>
<td>Private (non-profit)</td>
<td>74%</td>
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<tr>
<td>For Profit</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td><strong>Share of Total:</strong></td>
<td></td>
<td></td>
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<tr>
<td>Foreign Graduates</td>
<td>20%</td>
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</tr>
<tr>
<td>Graduate Enrollment</td>
<td>40%</td>
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<tr>
<td>1st Professional Degrees</td>
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<tr>
<td>Masters Degrees</td>
<td>38%</td>
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</tr>
<tr>
<td>Ph.D. Degrees</td>
<td>10%</td>
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</table>

Note: Statistics calculated from IPEDS 1995 Fall Enrollment, Completions, and Institutional Characteristics surveys. Sample includes institutions that are of the Baccalaureate level or higher. Universities are defined as "Research" if they are ever classified as a Doctoral/Research university in the 1994, 2000, 2005, or 2010 Carnegie Classifications.
### Table 2: 2SLS Results, Native Enrollment

<table>
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<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(9)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Main</td>
<td>Outliers</td>
<td>OLS</td>
</tr>
</tbody>
</table>

#### Panel A
**Boom 1995-2001**

<p>| | | | |</p>
<table>
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<tr>
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<tbody>
<tr>
<td>Int'l Graduate Flow</td>
<td>1.59**</td>
<td>1.30**</td>
<td>0.66</td>
</tr>
<tr>
<td></td>
<td>(0.70)</td>
<td>(0.59)</td>
<td>(0.45)</td>
</tr>
<tr>
<td># of Universities</td>
<td>292</td>
<td>258</td>
<td>292</td>
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<tr>
<td>N</td>
<td>1,752</td>
<td>1,548</td>
<td>1,752</td>
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<tr>
<td>1st Stage F-statistic</td>
<td>20.86</td>
<td>46.55</td>
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#### Panel B
**Bust 2002-2005**

<p>| | | | |</p>
<table>
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</thead>
<tbody>
<tr>
<td>Int'l Graduate Flow</td>
<td>0.80</td>
<td>1.59*</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>(0.75)</td>
<td>(0.85)</td>
<td>(0.31)</td>
</tr>
<tr>
<td># of Universities</td>
<td>292</td>
<td>258</td>
<td>292</td>
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<tr>
<td>N</td>
<td>876</td>
<td>774</td>
<td>876</td>
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<tr>
<td>1st Stage F-statistic</td>
<td>13.55</td>
<td>20.79</td>
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Note: ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered at the university level. All regressions include period effects and university fixed effects. Models are estimated using the panel fixed effects estimator. All regressions are weighted by initial total graduate enrollment.
Table 3: 2SLS Results, Natives by Field of Study -

<table>
<thead>
<tr>
<th></th>
<th>(1) - STEM (wide)</th>
<th>(2) - STEM (narrow)</th>
<th>(3) - Non-STEM Fields (Business and Education)</th>
<th># of Univ.</th>
<th>N</th>
<th>1st Stage F-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Boom 1995-2001</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main</td>
<td>1.24***</td>
<td>0.90***</td>
<td>0.43</td>
<td>239</td>
<td>1,434</td>
<td>14.80</td>
</tr>
<tr>
<td></td>
<td>(0.37)</td>
<td>(0.26)</td>
<td>(0.53)</td>
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<tr>
<td>Outliers</td>
<td>1.32***</td>
<td>0.87***</td>
<td>0.51</td>
<td>210</td>
<td>1,260</td>
<td>33.01</td>
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<td></td>
<td>(0.30)</td>
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<tr>
<td>OLS</td>
<td>0.02</td>
<td>0.03</td>
<td>0.09**</td>
<td>239</td>
<td>1,434</td>
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<tr>
<td></td>
<td>(0.02)</td>
<td>(0.02)</td>
<td>(0.05)</td>
<td></td>
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<tr>
<td><strong>Panel B</strong></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td><strong>Bust 2002-2005</strong></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Main</td>
<td>-0.11</td>
<td>-0.01</td>
<td>0.20</td>
<td>239</td>
<td>716</td>
<td>8.45 -</td>
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<tr>
<td></td>
<td>(0.21)</td>
<td>(0.12)</td>
<td>(0.54)</td>
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</tr>
<tr>
<td>Outliers -</td>
<td>0.26</td>
<td>0.12</td>
<td>0.44</td>
<td>210</td>
<td>629</td>
<td>12.93 -</td>
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<td></td>
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<td>(0.12)</td>
<td>(0.77)</td>
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</tr>
<tr>
<td>OLS -</td>
<td>-0.03</td>
<td>-0.02</td>
<td>0.00</td>
<td>239</td>
<td>716</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.03)</td>
<td>(0.08)</td>
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</table>

Note: ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered at the university level. All regressions include period effects and university fixed effects. Models are estimated using 2SLS. All regressions are weighted by initial total graduate enrollment.
Table 4: 2SLS Results on Faculty, Boom and Bust

<table>
<thead>
<tr>
<th></th>
<th>Boom 1995-2001</th>
<th></th>
<th>Bust 2002-2005</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td></td>
<td>Tenure-Track</td>
<td>Instructional</td>
<td>Tenure-Track</td>
<td>Instructional</td>
</tr>
<tr>
<td></td>
<td>Faculty</td>
<td>Faculty (Non-tenure Track)</td>
<td>Faculty</td>
<td>Faculty (Non-tenure Track)</td>
</tr>
<tr>
<td>Note: ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered at the university level. All regressions include period effects and university fixed effects. Models are estimated using 2SLS. All regressions are weighted by initial total graduate enrollment. -</td>
<td></td>
<td></td>
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</table>