THE IMPACT OF FOREIGN STUDENTS ON NATIVE ENROLLMENT IN GRADUATE PROGRAMS

George J. Borjas
Harvard University

October 2003

THE IMPACT OF FOREIGN STUDENTS ON NATIVE ENROLLMENT IN GRADUATE PROGRAMS

George J. Borjas

Abstract

This paper examines how the growth in the number of foreign students enrolled in graduate programs affects native enrollment in those programs. The study uses data drawn from the Integrated Postsecondary Education Data System (IPEDS) and the Survey of Earned Doctorates (SED). Although there is little evidence of a crowdout effect for the typical native student, the impact of foreign students on native educational outcomes differs dramatically across ethnic groups, and is particularly adverse for white native men. There is a strong negative correlation between increases in the number of foreign students enrolled *at a particular university* and the number of white native men in that university's graduate program and the number of white native men awarded doctoral degrees. This crowdout effect is strongest at the most elite institutions.

THE IMPACT OF FOREIGN STUDENTS ON NATIVE ENROLLMENT IN GRADUATE PROGRAMS

George J. Borjas*

I. Introduction

The Immigration and Nationality Act provides two types of "nonimmigrant" (i.e., non-permanent) visas for persons wishing to study in the United States. The "F-1" visa is for academic studies, and the "M-1" visa is for vocational studies. The number of visas issued to foreign students increased greatly in recent decades. In 1980, 155.0 thousand foreigners were granted temporary visas to study in the United States. By 2000, the number of student visas totaled 315.4 thousand, with the bulk of the visas (98.0 percent) being granted to persons enrolled in academic programs.[1]

As a result of the increasing number of visas granted to foreign students, the ethnic composition of students in higher education has changed dramatically, particularly at the graduate level. The share of nonresident aliens enrolled in graduate programs rose from 5.5 percent in 1976 to 12.4 percent in 1999.[2] The impact is even greater in some educational programs. For example, nonresident aliens receive a disproportionately high share of the doctoral degrees awarded in the physical sciences (38.2 percent of all doctorates awarded in 1999-2000), engineering (52.1 percent), the life sciences (26.6 percent), and the social sciences (22.8

* Robert W. Scrivner Professor of Economics and Social Policy, Kennedy School of Government, Harvard University; and Research Associate, National Bureau of Economic Research. I am grateful to Charles Clotfelter, Ronald Ehrenberg, Richard Freeman, Daniel Hamermesh, David Jaeger, and Michael Rothschild for helpful comments, to Davin Chor for research assistance, and to the Sloan Foundation for financial support.

[1] Borjas (2002) provides a detailed description of how the foreign student program works and presents a framework for evaluating the contributions of the program.

[2] U.S. Department of Education (2002), Table 208.

percent). In contrast, nonresident aliens received only 9.2 percent of the doctorates awarded in education.[3]

Despite the dramatic impact of foreign students on the higher education sector, it seems that the program has grown with little systematic thinking on whether such a large-scale visa program is beneficial. Remarkably, there has been practically *no* research analyzing the costs and benefits of foreign students. We know almost nothing about their impact on the higher education system, their impact on the U.S. labor market, and their impact on the economies of the source countries. In contrast to the voluminous literature that analyzes the labor market consequences of immigration, there has not been any analysis of the impact of foreign students on the educational opportunities available to native persons, of the trends in the quality of foreign students, of the selection process that determine which foreign students remain in the country after completing their education, and of the costs and benefits that the increased diversity (as well as the ample availability of low-wage foreign teaching and research assistants) imparts on universities.[4]

This paper begins the process of examining some of the consequences of the foreign student program. In particular, it investigates how the rapid growth in the number of foreign students enrolled in graduate programs affected native enrollment in those programs. If the number of slots in graduate programs were fixed, any increase in the number of foreign students would crowd out natives who would presumably have filled those positions. Even if the graduate programs were expanding, an increase in the supply of foreign students might sufficiently alter

---

[3] U.S. Department of Education (2002), Table 275.

[4] The exceptions mainly include studies that examine how foreign-born teaching assistants affect the educational outcomes experienced by native-born undergraduates; see Borjas (2000), Fleisher, Hashimoto, and Weinberg (2002), and Jacobs and Friedman (1988). I will discuss other research more directly related to this paper in the next section.

incentives for natives to pursue some programs, particularly if many foreign students stay in the United States and reduce economic opportunities in some occupations.

I analyze these questions using graduate enrollment data drawn from the Integrated Postsecondary Education Data System (IPEDS) as well as data on doctoral degrees awarded from the Survey of Earned Doctorates (SED). On aggregate, the analysis shows that there is little evidence of a crowdout effect for the typical native. This result, however, masks a great deal of variation within the native population. In particular, the impact of foreign students on native educational outcomes differs dramatically across ethnic groups and between native men and women. The evidence reported below documents a strong negative correlation between increases in the number of foreign students enrolled *at a particular university* and the number of white native men enrolled in that university's graduate program. Similarly, the data reveal a significant negative correlation between the number of doctoral degrees awarded to foreign students by a particular school and the number of doctoral degrees awarded to white native men by that school. The study thus suggests that the growth in the size of the foreign student population has indeed altered the educational opportunities available to white native men.

II. The Crowdout Effect

A university's decision to admit additional foreign students to its graduate program obviously depends on many factors, including the relative quality of the applicants, the possibility that foreign students pay for a higher fraction of their education, the widespread adoption of the axiom that "diversity" is beneficial in a university setting, and the relative marginal products of the foreign and native students as employees of the university (since many graduate students typically work as research assistants or teaching assistants). Some of these

factors may imply that, other things being equal, admission officers would prefer to admit a foreign student over a native-born applicant.

The admission and eventual enrollment of foreign students alters the educational opportunities available to qualified natives in two distinct ways. First, it may be the case that the number of slots available in a particular graduate program is fixed in the short run. The enrollment of an additional foreign student would then necessarily imply that one fewer native student would be enrolled. This is the simplest and clearest case of a crowdout effect. Even if the university were expanding and admitting more foreign *and* more native students, there may still be a crowdout effect in the sense that native enrollment would have risen faster if the university had not increased its supply of foreign students. In the empirical analysis reported below, I adopt the conservative definition of a crowdout effect that requires native enrollment to actually fall (rather than not rise as much as it would have risen otherwise) when the number of foreign students increases.

The entry of foreign students can alter the educational decisions made by native students in another, less direct, way. In particular, an increase in the number of enrolled foreign students may affect the incentives that natives have to pursue some educational programs. Suppose, for instance, that many of the foreign students enrolled in a particular program (e.g., computer science) remain in the United States after graduation. One would then expect that wages in these computer-related occupations would fall and those occupations would become relatively less attractive to natives. The foreign students may still choose to enter those low-paying jobs because their career decisions are mainly guided by the fact that the student visa is perceived as providing an entry ticket into the United States, so that they would be comparing the low U.S. wage in a computer-related occupation with the even lower wage that would be available if they

remained in the source countries. In contrast, native students have many more career choices, and would shy away from applying to those educational programs where foreign students cluster. In the long run, this behavioral response would again imply that an increase in the enrollment of foreign students in a particular program would reduce the number of natives enrolled in that program.[5]

There is one important distinction between the two types of crowdout effects discussed above. The first crowdout effect is specific to a particular university—and indicates how native enrollment in that institution changes as the number of foreign students enrolled in that institution increases. The second crowdout effect results from an economy-wide behavioral response that effectively inhibits natives from pursuing particular educational programs in all universities (or perhaps from pursuing a graduate education altogether if the labor supply increase resulting from the foreign student program is sufficiently large in all fields). The empirical analysis presented below nets out these economy-wide fluctuations and examines the shifts that occur in native enrollment *within a particular university* as the size of the foreign student population increases. The study, therefore, will isolate the institution-specific type of crowdout effect.

The conjecture that immigrants adversely affect the economic opportunities of competing native workers in the labor market has long been a central component of the immigration debate. As a result, the resurgence of large-scale immigration in the past few decades motivated a great deal of research examining this issue (Grossman, 1982; Card, 1991; and Borjas, 2003). Although the evidence is mixed, more recent studies tend to conclude that immigration indeed lowers the earnings of similarly skilled native workers.

---

[5] Freeman et al (2001) describe how the major shifts in the bioscience job market, shifts that are partly due

Despite the rapid rise in the number of foreign students enrolled in graduate programs, however, there has been little systematic study of how foreign students alter the educational opportunities available to natives. Hoxby (1998) and Betts (1998) present some of the only evidence on this issue. Hoxby uses the National Postsecondary Student Aid Study to calculate the correlation between the fraction of a college's students who are black or disadvantaged and the fraction of the students who are foreign born, and finds the correlation to be negative. Using Census data, Betts finds that young black and Hispanic natives are less likely to have completed high school if they reside in areas where immigrants tend to cluster. The empirical analysis presented below differs from these initial studies in a number of ways. My study focuses specifically on crowdout effects in the graduate sector, and exploits the panel feature of the data to estimate institution-specific adjustments in native enrollment as the size of the foreign student population changes.

III. Data

Since 1986, the Integrated Postsecondary Education Data System (IPEDS) has collected detailed information on enrollment, employment, and finances in institutions of higher education. Each institution reports the number of persons enrolled in particular programs both at the undergraduate and graduate levels, including the gender and race of students, as well as the number of nonresident aliens (which, for simplicity, I will refer to as "foreign students"). The educational institution also reports detailed information on expenditures in various categories relevant to the higher education sector (e.g., instruction and research). Prior to 1986, the same type of information was collected by the Higher Education General Information System

---

to the influx of foreign students, alter the incentives for pursuing careers in that sector.

(HEGIS), a precursor of the IPEDS data. My empirical analysis uses enrollment information provided by both of these surveys.

My analysis focuses on enrollment trends in graduate programs. Unless specifically noted, these enrollment statistics do not include students who attend professional schools.[6] Further, the analysis is restricted to higher education institutions in the United States that are accredited at the college level by the U.S. Department of Education and that are legally authorized to offer at least a one-year program of study creditable to a degree.[7]

My empirical study of enrollment trends uses the cross-sections observed in 1978, 1982, 1986, 1990, 1994, and 1998. In each of these cross-sections, I calculate the total number of graduate students enrolled in each institution, regardless of whether they are enrolled full-time or part-time. The choice of the timing of the cross-section snapshots is due to two factors. Prior to the 1990s, the IPEDS surveys were not conducted annually, and some of the available cross-sections do not contain any information on the number of foreign students enrolled in the institution. Further, the four-year gap across cross-sections implies that there is a significant turnover in the graduate student population of a particular institution from survey to survey, minimizing the problems that would arise if many students were double-counted because they appeared in several surveys.[8] Because the IPEDS contains only limited information on field of study, I restrict the analysis to the size of the entire graduate program at a particular institution. I

---

[6] In the IPEDS file, professional students include students enrolled in professional programs in schools of law, medicine, and dentistry, but do not include students attending business or engineering schools. The business and engineering students are classified as graduate students, and are therefore included in the analysis that follows.

[7] Operationally, this sample restriction limits the study to institutions that have a valid Federal Interagency Committee on Education (FICE) code.

[8] Alternatively, I could have analyzed enrollment trends for first-time graduate students (an enrollment statistic that is also reported in the IPEDS). These data, however, seem to contain significant measurement errors, particularly in the earlier surveys.

will return below to a study of crowdout effects within fields using an alternative data set better suited for that purpose.

Table 1 summarizes the enrollment trends.[9] There has been a substantial increase in the number of foreign students enrolled in graduate programs. The number of foreign students more than doubled between 1978 and 1998, from 79.4 thousand to 194.3 thousand. Much of the growth in the size of the foreign student population in the 1990s can be attributed to the increase in the number of female foreign students. The number of male graduate students was roughly constant at around 118.0 thousand during this decade. In contrast, the number of female graduate students rose from 18.7 thousand in 1978 to 50.9 thousand in 1990, and to 73.4 thousand in 1998.

There has also been a sizable increase in the number of native-born graduate students. In 1978, there were 1.2 million native graduates students, and this number increased to 1.4 million in 1990, and to 1.6 million in 1998. It turns out, however, that *all* of this growth occurred among native women. The number of female native-born graduate students rose from 612 thousand in 1978 to 798 thousand in 1990, and to 938 thousand in 1998. In contrast, the number of male native-born students hovered around 600 thousand throughout the entire period.

There is one particular group of natives—white men—that will play a significant role in the empirical analysis reported below. They are the only native group that had a lower enrollment in graduate programs at the end of the period than at the beginning. In particular, there were 556.0 thousand white native men enrolled in graduate programs in 1978. This statistic

[9] There are some minor differences between the data reported in Table 1 and the official statistics published by the Department of Education in the *Digest of Education Statistics*. The total counts of students enrolled in graduate programs matches exactly in some survey years, but differs slightly (by less than 10 thousand students) in other years. These minor differences arise because the two calculations use slightly different sets of accredited institutions.

fell to 539 thousand in 1990, and to 509 thousand in 1998. It is worth noting, however, that graduate enrollment for this group did not decline monotonically throughout the period.

All other ethnic groups in the native population report (sometimes large) increases in graduate enrollment. For example, black graduate enrollment rose from 76.4 to 138.6 thousand between 1978 and 1998; Asian enrollment rose from 27.5 to 86.2 thousand; and Hispanic enrollment rose from 27.9 to 82.7 thousand.

IV. Estimating Crowdout Effects in Graduate Enrollment

This section addresses a simple question: What happens to the enrollment of natives when a university increases the number of foreign students enrolled in its graduate program?

Let N_{it} denote the number of native graduate students enrolled in university i at time t, and let F_{it} denote the respective number of foreign students. Much of the empirical analysis reported in this paper stacks the enrollment data obtained from the HEGIS and IPEDS across universities and surveys and estimates the regression model:

$$N_{it} = \theta F_{it} + s_i + \pi_t + \varepsilon_{ijt}, \tag{1}$$

where s_i is a vector of fixed effects indicating the university; and π_t is a vector of fixed effects indicating the time period. The university fixed effects absorb any university-specific factors that may determine the size of native enrollment. Similarly, the period fixed effects absorb any time-specific factors that determine the size of the native population interested in pursuing a graduate

education at a particular point in time.[10] Throughout the analysis, the regression will be weighted by the total enrollment of the graduate program in a particular university at a particular point in time (or $N_{it}+ F_{it}$). Further, the standard errors are clustered by university to adjust for possible serial correlation within a particular institution.

Under some conditions, the sign and magnitude of the coefficient θ can provide valuable information about the crowdout effect suggested by the enrollment data. In particular, note that θ measures what happens to native enrollment *within a particular university* when that institution decides to enroll one more foreign student. If the estimate of θ were zero, for example, the data would indicate that the enrollment of an additional foreign student simply expands the university above its current size and has no effect on its pre-existing (native) enrollment. If the estimate of θ were −1, however, the data would suggest a one-to-one crowdout effect. The total number of students enrolled in the university's graduate program is constant, and each additional foreign student simply displaces a native student who presumably would have otherwise enrolled. Of course, the regression analysis may also indicate that θ is positive, perhaps even exceeding one. Over time, some universities have expanded, and the coefficient θ would measure how the expansion affect affected the relative enrollment of natives and foreign students. The regression coefficient θ thus captures the net impact of expansion and crowdout effects.[11]

---

[10] Note that the period fixed effects capture the potential crowdout that arises as natives respond to the changed labor market opportunities caused by an increase in the number of foreign students. These wage effects would presumably reduce the incentives of natives to enroll in a graduate program at *any* university.

[11] Many universities expanded the size of their graduate program between 1978 and 1998. In particular, 54.4 percent of institutions increased their enrollment by at least 100 students, and only 16.5 percent cut their enrollment by at least 100 students. The fact that graduate enrollment grew in most universities suggests that it may be difficult to find significant evidence of a negative crowdout effect (i.e., $\theta < 0$), since the number of *both* foreign and native students enrolled in a particular graduate program probably grew concurrently.

The top panel of Table 2 presents the coefficient θ estimated from the basic specification of the model. To better understand the presentation of the results, consider the first coefficient reported in the table, where the dependent variable is the total number of natives (both men and women) enrolled in school *i* at time *t* and the independent variable gives the total number of foreign students enrolled in that school at that time. The estimated coefficient is .046 (with a standard error of .279), indicating that each additional foreign student enrolled in this program, at the margin, had essentially no impact on the number of natives enrolled at that institution.[12]

It turns out, however, that this aggregate correlation masks a great deal of variation in the data, particularly in terms of the impact of foreign students on the enrollment of natives who differ in their gender and ethnic background. The second and third columns of the first row report the estimated coefficients when the dependent variable measures graduate enrollment for native men and women separately. It is evident that the weak correlation revealed by the first column is essentially obtained by adding a negative (though imprecisely measured) impact of foreign students on male enrollment and a positive impact of foreign students on female enrollment. In particular, each additional foreign student is associated with a reduction in the number of male students of -.198 (.152), and an increase in the number of female students of .244 (.141). The data seems to be indicating, therefore, that crowdout effects, if they exist at all, are likely to be concentrated in the sample of male natives.

The remaining rows of the top panel of Table 2 estimate the same generic regression but define the dependent variable as the number of natives within particular race and ethnic groups, specifically Asians, blacks, Hispanics, and white natives. The difference in the impact of foreign students on the enrollment of natives belonging to different ethnic categories is quite striking.

---

[12] The estimate of θ would be 3.210 (.256) if the institution fixed effects were not included in the

For example, there is a positive and significant correlation between foreign students and the enrollment of Asian, black, and Hispanic natives. In contrast, there is a significant negative correlation between foreign students and the enrollment of white natives. For white natives, the coefficient is -.488 (.268).

It is important to note that the negative coefficient estimated for white natives, and particularly for white native men, does *not* indicate that graduate enrollment for this group was declining at every university. That potential trend is absorbed by the period dummies included in the regression model. Instead, the estimated coefficient indicates that the enrollment of white native men fell most in those schools that had larger increases in the number of foreign students enrolled. In short, the evidence suggests a significant *institution-specific* crowdout effect of foreign students on the enrollment of white men.[13]

The nature of the data underlying the estimated crowdout effect for white native men can be easily illustrated. Figure 1 presents the scatter diagram that relates the 1978-98 change in the enrollment of white native men to the respective change in the number of foreign students enrolled at a particular university. Each point in the scatter diagram, therefore, represents enrollment changes that occurred at a school over the period. It is clear that the enrollment of white native men fell most steeply in those schools that had the largest increases in foreign student enrollment.

Although I have restricted the analysis to students enrolled in graduate programs, it is possible that natives crowded out of slots in graduate departments switch to other parts of the higher education sector, particularly professional schools of law and medicine (which have, in

---

regression.

fact, enrolled relatively few foreign students in the past two decades). As Panel B of Table 2 shows, the coefficient θ for the most affected group—white native men—is actually more negative when I use this more expansive definition of graduate enrollment. In particular, the coefficient is -.576 (.145). In short, for every two additional foreign students enrolled in graduate and professional programs at a particular university, roughly one fewer native ended up attending these programs. There is no evidence, therefore, suggesting that the restriction to enrollment in graduate programs (which I will use throughout the remainder of the analysis) misses an important part of the substitution that takes place as some natives respond to the possible crowdout effects of foreign students.

Because graduate education for both foreign and native students is highly subsidized by U.S. taxpayers (Winston, 1999), it is of interest to determine if the crowdout effect differs between public and private institutions.[14] Table 3 estimates the basic regression model in each of the two sectors. The evidence indicates that the crowdout effect on white native men is negative and significant in both sectors, but is substantially larger in private universities. In particular, the coefficient θ is -.272 (.139) for public universities and -.589 (.222) for private universities. It is also worth noting that the regressions for white native *women* also suggest the existence of a potentially important crowdout effect in private institutions. The coefficient for white native women is -.267 (.239). As a result of the sizable crowdout effects for all white natives enrolled in private universities, the coefficient for total white native enrollment in this sector is -.856 (.428),

---

[13] The strong evidence for crowdout effects among white native men would remain if the regressions were not weighted by the size of the graduate program at the university. The crowdout coefficient in the unweighted regression is -.316 (.096).

[14] Although public institutions presumably receive a larger share of taxpayer subsidies, graduate education in private institutions is also heavily subsidized by public funds.

essentially indicating a one-to-one displacement of white natives as foreign student enrollment increases.

It is also important to show that the crowdout effect of foreign students on white native men isolates a unique relationship that is not found when one contrasts the enrollment trends of white native men with other groups. As I showed in the last section, the 1980s and 1990s were accompanied not only by large increases in foreign enrollment, but also by a very large increase in the number of native women who chose to enroll in graduate programs. It is of interest, therefore, to determine if the enrollment of white men reacts to an increase in the number of native women in the same way that it reacts to an increase in the number of foreign students.

To determine this correlation, I estimate a slightly different version of the regression model in equation (1). In particular, I now use the number of native women as a regressor (instead of the number of foreign students). Specification 1 in Table 4 shows that there is a positive, rather than a negative, correlation between the enrollment of native white men and native women. The reason for this result is revealed by the scatter diagram presented in Figure 2, which shows the relationship between the 1978-1998 change in enrollment for the two groups. The enrollment of white native men grew most (or, better put, decreased least) in those schools where the enrollment of white native women also grew the most.

Specification 2 in Table 4 generalizes the regression model to examine how the enrollment of white native men responded to increases in both the number of foreign students and the number of native women. The results again indicate that the negative impact of foreign students on the enrollment of white native men is unique. Increases in native female enrollment did not reduce the number of white native men enrolled at the university, while increases in the enrollment of foreign students did.

Crowdout and School Quality

It is unlikely that the foreign student population is randomly distributed across graduate programs in the United States. Any cost-benefit assessment of the crowdout effect documented above obviously depends on the nature of the constraints that the enrollment of foreign students imposes on the educational access available to natives. As a result, it is important to examine how the crowdout effect varies across institutions that differ in the quality of their graduate programs.

To assign a quality ranking to a particular institution, I used the data on instructional expenditures reported in the IPEDS files. I calculated the *average* per-student instructional expenditures for the survey years 1990-1993.[15] The averaging of the expenditure data over the four years helps to minimize the problem of both measurement error and short-run fluctuations in instructional expenditures. I restricted the set of institutions to those that reported an average per-student expenditure of less than $100,000. This restriction eliminates almost all medical schools, law schools, and theological schools from the data. I then divided the remaining population of institutions into 50 quantiles. There are approximately 1,100 institutions in my data extract, so that each quantile of the distribution contains around 22 schools.[16] The top two quantiles of this distribution contain the list of "usual suspects," including Harvard, Yale, Princeton, Columbia, and the California Institute of Technology.

---

[15] The denominator includes all undergraduate and graduate students, regardless of whether they are enrolled part-time or full-time. The expenditure data was deflated using the CPI-U series.

[16] The data on instructional expenditures is not available for approximately 20 percent of the institutions. These institutions are omitted from the analysis reported in this subsection.

It is instructive to illustrate how the enrollment of native and foreign students varies among the institutions defined in terms of these 50 quality quantiles. Figure 3 presents the cumulative distributions of foreign and native students. There is a marked difference in the distributions of the two groups. In particular, native enrollment is much more evenly distributed across the 50 quantiles of the quality distribution than is foreign enrollment. For instance, 48.0 percent of natives are enrolled in schools in the bottom 30 quantiles of the quality distribution, as compared to only 22.8 percent of foreign students.

Equally important, there is an important difference in how enrollment grew over the 1978-1998 period for foreign and native students across the various quantiles of the quality distribution. Figure 4 shows that native enrollment tended to grow fastest at the lower-quality institutions, while the enrollment growth of foreign students tends to rise steadily with the quality measure.

Figure 4 again suggests that the crowdout effect of foreign students on white native men isolates a unique relationship that is not found when one contrasts the enrollment trends of white native men with other groups. In particular, the figure shows that native women are much more evenly scattered across the quality spectrum, so that the growth of women occurred in the same types of institutions where the enrollment of white native men grew most (or decreased least). In short, there is no evidence that the increase in the supply of native women in graduate programs crowded out native white men.

Table 5 reports the coefficient θ from regression models estimated separately in sets of institutions of roughly similar quality. In particular, I estimate the crowdout model in the set of institutions in the bottom 10 quantiles, in quantiles 11 through 40, in the top 10 quantiles (41-50), as well as in the "elite" institutions that occupy the 50^{th} quantile. The results are quite

striking. The correlation between the enrollment of white native men and foreign students is slightly positive for the low-quality schools (.188, with a standard error of .281), turns zero for schools in the middle of the quality distribution (-.038, with a standard error of .140), and becomes quite negative for schools at the top of the distribution (-.493, with a standard error of .167). In fact, the coefficient is most negative when the regression model is estimated in the subset of elite institutions in the 50^{th} quantile. Among these institutions, the crowdout effect for white native men is -.605, with a standard error of .253. In fact, the table suggests that there is also a crowdout effect for white native *women* at these elite institutions. The coefficient for white native women is -.277, with a standard error of .236.

Alternative Interpretations

Although my discussion of the regression results has interpreted the negative sign of the coefficient θ for white native men as evidence of a "crowdout effect," it is worth examining if there are alternative hypotheses that might explain the results for this group.

One simple alternative hypothesis is that the decline in the number of white native men enrolled in graduate programs reflects a decline in the number of white native men who could be potential graduate students. One problem with this alternative story is that the regressions already control for demographic trends by including a vector of period fixed effects. These fixed effects absorb the impact of any variable—such as a change in the size of the available pool of potential graduate students—that is fixed at a particular point in time.

Moreover, the evidence regarding the demographic trends does not seem to be consistent with the trends in the enrollment of white native men in graduate programs. Figure 5 uses data from the decennial Censuses in 1970, 1980 and 1990, as well as the 1994 and 1998 Current

Population Surveys to calculate the number of white native men aged 22-28 who are college graduates. This population consists of the pool of persons who are presumably the potential consumers of graduate programs. As the figure shows, the pool of potential graduate students among white native men rose dramatically between 1970 and 1980 (as the baby boomers reached their 20s), and declined by about 200 thousand persons since then, with almost all of the decline occurring between 1980 and 1990. In contrast, the number of white men enrolled in graduate programs shows a slight cyclical fluctuation but has been hovering between 500 and 550 thousand throughout the past two decades. In short, the evidence does not suggest that graduate enrollment of white native men declined faster in those periods when the pool of potential graduate students was shrinking the most.[17]

There is also the possibility that the results summarized in the crowdout regressions are capturing a reverse causality. The institutions increased their enrollment of foreign graduate students because they faced a substantial decline in the number of (qualified) white native men who wished to enroll in graduate programs.

This counterfactual resembles the often-heard argument that "immigrants do jobs that natives do not want to do" in the U.S. labor market. If one takes this set of arguments seriously, it would seem to imply that there are few jobs that natives *do* want to do. After all, the argument is used to justify why immigrants do not compete with low-skill workers, such as gardeners, taxi drivers, and maids—since natives do not want to perform those presumably menial jobs. It is also used to justify why high-tech immigrants who enter the United States through the H1-B program do not compete with natives in the high-tech sector—since natives do not want to be

[17] The demographic hypothesis also fails to explain why the evidence suggests a crowdout effect for white native women enrolled in private universities or in elite institutions. After all, the number of white native women enrolled in graduate programs grew rapidly in the past two decades.

software programmers. And, in the current context, it is used to explain why immigrants do not crowd out natives from graduate programs, since white native men no longer wish to attend graduate school.

It is unlikely that this conjecture can be true in the current context (if it is ever true in any context!). After all, the greatest declines in the enrollment of white native men occurred at high-quality institutions. Surely all potential graduate students—regardless of their race and ethnic background—would prefer to attend those institutions that provide the best job market opportunities after graduation.[18]

In sum, the evidence summarized in this section documents a strong negative correlation between the enrollment of white native men in graduate programs and the enrollment of foreign students. Those educational institutions that experienced the largest increases in foreign enrollment are also the institutions that experienced the steepest drops in the enrollment of white native men. The evidence is consistent with the hypothesis that foreign students limit the opportunities available to white native men in graduate education, particularly at the most elite institutions. It would seem, therefore, that any assessment of the foreign student program must include an accounting of the cost that the program imposes on a sizable part of the native population in terms of foregone educational opportunities.

---

[18] Of course, it is possible that it is the most qualified white native men who do not want to attend graduate school any longer, so that graduate programs have a shortage of qualified applicants in this group, and are forced to fill in the existing slots with foreign applicants. But the question remains: what exactly do these white native men do now that they no longer attend graduate school? Related work by Groen and Rizzo (2003) show that the probability that native white men who have just graduated from college go on to get a Ph.D. was relatively constant over the 1980-2000 period.

V. Estimating Crowdout Effects in Earned Doctorates

The previous section estimated the correlations between the enrollment of native and foreign students in graduate programs. I now examine if the crowdout effect for some native groups can also be observed in terms of a key "outcome" variable in the higher education sector, the number of doctorates granted to native students.

The analysis uses data drawn from the Survey of Earned Doctorates (SED), a data file collected and maintained by the National Science Foundation. This micro data file is effectively a population census of all persons who receive doctorates in a particular calendar year, with a response rate of around 90 percent. I restrict the analysis to persons who received their doctoral degree from a U.S. institution between 1975 and 1998. I aggregate the individual data to the level of an educational institution, so as to calculate the number of doctorates awarded by an institution to particular groups at a point in time. The SED collects information on whether the doctoral recipient had a temporary visa at the time that the doctorate was awarded. I use this variable to calculate the number of doctorates awarded to foreign students and to "natives" (all the doctoral recipients who were citizens or permanent residents at the time they received their doctorate). As before, the study will use information on the doctoral recipient's race and sex to determine if the crowdout effect of foreign students differs across various groups of native students.

There is a great deal of short-run variation in the number of doctorates awarded by particular institutions over time. To eliminate some of this variation, I aggregate the data into four-year brackets: 1975-78, 1979-82, 1983-86, 1987-90, 1991-94, and 1995-98. An observation in my data extract, therefore, provides information on the number of doctorates awarded by a particular institution in a particular four-year time period.

Table 6 begins the analysis of the SED data by reporting the trends in the number of doctorates granted to native and foreign students between 1975 and 1998. As is well known, there has been a substantial rise in the number of doctorates awarded to foreign students in the past two decades. Between 1975 and 1978, 14.0 thousand foreign students received doctorates, and this statistic almost tripled to 37.3 thousand by 1995-98. In contrast, the number of natives receiving doctorates rose by only 16 percent, from 113.6 to 131.6 thousand. As suggested by the enrollment data presented in the previous section, the number of white native men receiving doctorates declined from 83.4 to 71.0 thousand, while the number of native women receiving doctorates doubled from 30.1 to 60.7 thousand.

Table 7 estimates the generic crowdout regression model using the SED data. The dependent variable is the number of native doctorates (in a particular ethnic and gender group) awarded by a particular institution during a four-year time period. The regressions are weighted by the size of total graduate enrollment in that institution. This statistic is obtained from the IPEDS data used in the previous section, and gives total graduate enrollment observed at the end of each four-year time bracket. Finally, the standard errors are clustered by university to adjust for possible serial correlation.

The results reported in Panel A of Table 7 are similar to those obtained from the enrollment data in the IPEDS. Overall, there is only a weak correlation between the number of doctoral degrees awarded to natives and the number of doctoral degrees awarded to foreign students *within a particular institution*. It turns out, however, that this weak correlation masks a substantial difference between the correlation for male natives and female natives. In particular, the estimated coefficient θ is negative and significant for men (-.233, with a standard error of .120), and positive and significant for women (.381, with a standard error of .071). As in the

previous section, the largest crowdout effects are estimated for white native men, where the estimated coefficient is -.242 (.081).

As before, the underlying data responsible for the crowdout effect found in the sample of white native men is easy to illustrate. Figure 6 presents the scatter diagram relating the change between 1975-78 and 1995-98 in the number of doctorates earned at a particular university by foreign students and white native men. The scatter has an obvious negative slope, indicating that the number of white native men earning doctorates declined the most in those universities that had the largest increases in earned doctorates by foreign students.

The bottom two panels of Table 7 replicate the analysis for public and private universities. As with the enrollment data, the crowdout effects are strongest for white native men enrolled in private institutions, where the coefficient is -.405 (.117). This contrasts with a crowdout effect of -.229 (.096) for white native men enrolled in public institutions.

Unlike the IPEDS, the SED data provides detailed information on the field in which the persons received their doctoral degrees, making it possible to estimate crowdout effects within particular fields. I aggregated the SED data into ten general fields, and estimated the crowdout model separately in each of these fields. The dependent variable in these regressions, therefore, is the number of doctorates awarded in a particular field by a particular institution during a particular time period. Table 8 reports the results. The crowdout coefficient for white native men is negative in five out of the ten fields, and is negative in the three fields that account for the largest number of doctoral degrees: biological sciences (-.266, with a standard error of .076), social sciences (-.385, with a standard error of .144), and physical sciences (-.122, with a standard error of .089).

Finally, it is important to note that there is a significant difference in the magnitude of the crowdout effect across institutions of different qualities. There are 323 institutions in my data that award doctorates and that have valid data on per-student instructional expenditures. To obtain relatively large samples within each quality grouping, I grouped institutions into a 20-quantile quality distribution. Each quantile, therefore, contains approximately 16 institutions. For each quantile, I calculated the difference between the total number of doctoral degrees awarded to white native men or foreign students in 1995-98 and the corresponding number awarded in 1975-78. Figure 7 illustrates the evidence. The decline in the number of doctorates awarded to white native men was greatest in the high-quality institutions, precisely the institutions that experienced the largest increase in the number of doctorates awarded to foreign students. The figure also shows that the increase in the number of doctorates awarded to native women is more evenly scattered across the quality spectrum than that of foreign students.

Table 9 summarizes this evidence in a regression format by estimating the crowdout model in particular sets of institutions differentiated by quality. It is evident that the crowdout effect is much larger in the more elite institutions. In the case of white native men, for example, the coefficient is .647 (.103) in institutions that are in the lowest 10 quantiles of the quality distribution; -.098 (.138) in the institutions between the 11^{th} and 40^{th} quantiles; and -.302 (.097) in the institutions in the top 10 quantiles. In fact, the crowdout effect is -.701 (.146) in the elite institutions that occupy the 50^{th} quantile of the quality distribution. It is also worth noting that foreign students also have a significant crowdout effect for white native women in these elite institutions. The crowdout coefficient is -.389 (.273). In fact, the sum of the crowdout effects for white men and white women implies that an additional foreign student earning a doctorate in the

most elite institutions is associated with a decline of one white native earning a doctorate at those institutions.

Affirmative Action and Crowdout Effects

Up to this point, the analysis has ignored the racial background of the foreign student population. It is possible, however, that university admission officers consider such factors as the race and gender of foreign students so that they can tally some foreign students as belonging to particular minority groups. For example, a Hispanic foreign student could be used to increase the count of Hispanics enrolled at a university. This decision would then allow the university to meet certain affirmative action goals without having to admit a less-qualified Hispanic native.

The SED data (unlike the IPEDS) reports the ethnic and racial background of all doctoral recipients, including the foreign students. I classify the foreign students into the following categories: Hispanic, non-Hispanic Asian, non-Hispanic black, non-Hispanic white; and "other". As Figure 8 shows, there are sizable differences in the trends of doctorates awarded to these various groups. In fact, much of the growth in the number of doctorates awarded to foreign students can be attributed to an increase in the number of Asian doctoral recipients. The number of doctorates awarded to Asians rose from 4.9 thousand in 1975-98 to 23.3 thousand in 1995-98. In contrast, the number of doctorates awarded to white foreign students rose only from 5.6 to 9.4 thousand.

Table 10 estimates a slightly more general specification of the crowdout regression model. In particular, the foreign student variable is replaced by a vector of variables indicating the number of foreign students in the various race groups. The estimated coefficients yield two interesting results. First, there is no evidence to suggest that the number of doctorates awarded to

foreign students in a particular racial group has an adverse effect on the number of doctorates awarded to natives in that same racial group. For example, an increase of 10 Asian foreign students is associated with an increase of 2.0 Asian natives earning doctorates. Similarly, an increase of 10 black foreign students is associated with an increase of 6.0 black natives earning doctorates. Finally, an increase of 10 Hispanic foreign students is associated with an increase of 2.3 native Hispanics earning doctorates. Second, the results suggest that the crowdout effect on white native men can be mostly attributed to the large increase in the number of Asian foreign doctoral recipients. This is not surprising since Asians account for practically all of the growth in the number of doctoral degrees awarded to foreign students.

VI. Policy Implications of Crowdout Effects

It is far from clear that the crowdout effect of foreign students on the enrollment of white native men (and sometimes white native women) in graduate programs signals a suboptimal allocation of resources in the higher education sector. The policy implications of the finding—as well as the recommended policy tools that can be used to adjust the outcomes—depend crucially on three related issues. First, what happens to the displaced white native men? Second, what happens to the foreign students after they complete their education? And third, what are the benefits that the foreign student program imparts on universities and the U.S. labor market?

The first of these questions is perhaps the most difficult question to answer, as we simply do not know the career choices made by the displaced white men (and it is difficult to imagine a simple way of observing these career choices). Did these men move on to lower-quality graduate programs, or did many of them decide to forego a graduate education altogether? Moreover, any

cost-benefit analysis requires information on how these men would have fared had they attended the graduate program of their choice (in the absence of foreign students).

We could potentially learn much more about the career choices and economic contributions made by the foreign students after they complete their graduate education. Finn (2000) and Finn, Pennington, and Anderson (1995) estimate the stay rate for nonresident aliens who receive their doctorates in the United States. The stay rate was around 42 percent for foreigners who received their doctorates in the 1980s, but increased to around 53 percent for those who received their doctorates in 1992. These data suggest a number of important questions that have not been sufficiently analyzed: What is the nature of the selection that determines the population of stayers? How has this selection changed over time, as the number of foreign students enrolled in graduate programs increased? And how do the foreign students who remain in the United States fare in the labor market?[19]

Finally, the foreign graduate students, both those who stay in the United States as well as those who go back, impart additional costs and benefits on the country. For example, foreign students pay tuition, and these tuition revenues—if they were to exceed the actual cost of providing the education to the foreign students—could be an additional source of economic benefit. It turns out, however, that the pricing of higher education in the United States is highly distorted in both private and public institutions, with the typical tuition payment not being sufficiently large to cover the actual cost of the education (even in the absence of financial aid). Winston (1999) estimates that the *average* per-student subsidy (in 2001 dollars) is $8,800 in private universities and $10,000 in public universities, with the subsidy being substantially higher at the most elite institutions. In short, even if the foreign graduate students enrolled at

public universities paid the full nominal tuition, their payments would fail to cover the true cost of their education since both public and private universities receive substantial taxpayer subsidies.

In fact, these large subsidies introduce a difficult wrinkle in any policy discussion of the crowdout effect. If immigration policy is supposed to benefit the native population, it is difficult to justify a subsidy system that limits educational opportunities for a large group of native students unless the economic gains from foreign students are very large.

However, the available evidence on the economic gains from immigration suggests that (in the absence of externalities) these gains are likely to be small. The "textbook" model of the economic impact of immigration suggests that immigration reduces the total income accruing to native-born workers, while raising the profits of the firms that employ those workers. The gains accruing to the firms exceed the total losses accruing to the workers, so that the nation as a whole gains. The existing studies conclude that a 10 percent increase in labor supply due to immigration almost certainly increases the GDP accruing to the native population by about 0.1 percent, or less than $10 billion a year (Borjas, 1995; Johnson, 1998; Smith and Edmonston, 1997).

A fraction of this $10 billion net gain should be attributed to the economic gains associated with the employment of low-wage foreign student workers in American universities and to the economic contributions of the foreign students who remain in the United States. Although the size of these populations is relatively small, it is likely that they make a disproportionate contribution to economic activity and may even generate sizable externalities.

---

[19] One could also incorporate into the cost-benefit analysis the contributions made by foreign students who return to their source countries.

For example, it is well documented that foreign doctorates who reside in the United States contribute significantly to the advancement of science (Stephan and Levin, 2001).

VII. Conclusion

The number of foreign students enrolled in graduate programs increased dramatically in the past two decades. At some universities, in fact, foreign students now make up the majority of graduate enrollment in many fields. Despite the rapid growth in the size of the foreign student population, little is known about the educational and economic consequences of the program. This paper is an attempt to begin a systematic appraisal of the role that foreign students play in the higher education system.

The paper addresses a simple question: does the enrollment of foreign students in graduate programs alter the educational opportunities available to natives? I used data drawn from the Integrated Postsecondary Educational Data System (IPEDS) and the Survey of Earned Doctorates (SED) to examine the link between the admission of foreign students and the enrollment and educational outcomes of various groups of natives, differentiated by gender and ethnicity.

On aggregate, there is little evidence that foreign students displace the typical native from a graduate education. This finding, however, hides a great deal of variation in the impact of foreign students on the educational outcomes experienced by different ethnic groups in the native population, as well as between native men and women. Although the number of native women or native minorities enrolled at a particular university increased at the same time that the number of foreign students was rising, there was also a substantial decline in both the number of white native men enrolled in those graduate programs and in the number of white native men receiving

doctoral degrees. Moreover, the crowdout effect for white native men was strongest at the most elite graduate institutions.

It is difficult to determine if this crowdout effect is ultimately beneficial or harmful for the United States. The foreign students enrolled in the graduate programs—many of whom remain in the country after completing their education—may be better qualified than the displaced natives who would have otherwise attended those programs. However, the graduate education of both foreign and native students is heavily subsidized by the government. These subsidies are, in effect, being used to displace many white native men from a graduate education in high-quality schools. Any assessment of the foreign student program will obviously require some information on the long-run outcomes experienced by the displaced natives, as well as a full accounting of the costs and benefits that the foreign student program imparts on the U.S. economy.

References

Betts, Julian R. "Educational Crowding Out: Do Immigrants Affect the Educational Attainment of American Minorities," in Daniel S. Hamermesh and Frank D. Bean, eds., *Help or Hindrance: The Economic Implications of Immigration for African Americans*. New York: Russell Sage Foundation, 1998.

Borjas, George J. "The Economics of Immigration," *Journal of Economic Literature*, December 1994, pp. 1667-1717.

Borjas, George J. "The Economic Benefits from Immigration," *Journal of Economic Perspectives*, Spring 1995, pp. 3-22.

Borjas, George J. "Foreign-Born Teaching Assistants and the Academic Performance of Undergraduates," *American Economic Review*, May 2000, pp. 355-359.

Borjas, George J. *An Evaluation of the Foreign Student Program*, Center for Immigration Studies, Washington, DC, June 2002.

Borjas, George J. "The Labor Demand Curve *Is* Downward Sloping: Reexamining the Impact of Immigration on the Labor Market," *Quarterly Journal of Economics*, forthcoming 2003.

Card, David, "The Impact of the Mariel Boatlift on the Miami Labor Market," *Industrial and Labor Relations Review*, January 1990, pp. 245-257.

Finn, Michael. *Stay Rates of Foreign Doctorate Recipients from U.S. Universities*. Oak Ridge, TN: Oak Ridge Institute for Science and Engineering, 2000.

Finn, Michael, Leigh Ann Pennington, and Kathryn Hart Anderson. *Foreign Nationals Who Receive Science or Engineering Ph.D.s from U.S. Universities: Stay Rates and Characteristics of Stayers*. Oak Ridge, TN: Oak Ridge Institute for Science and Education, 1995.

Fleisher, Belton, Masanori Hashimoto, Bruce Weinberg, "Foreign GTAs Can Be Effective Teachers of Economics," *Journal of Economic Education*, Fall 2002, pp. 299-325.

Freeman, Richard B., Eric Weinstein, Elizabeth Marincola, Janet Rosenbaum, and Frank Solomon. "Competition and Careers in Bioscience," *Science*, December 14, 2001, pp. 2293-2294.

Grossman, Jean Baldwin. "The Substitutability of Natives and Immigrants in Production," *Review of Economics and Statistics*, November 1982, pp. 596-603.

Groen, Jeffrey A. and Michael J. Rizzo, "The Changing Composition of American Citizen PhDs," paper presented at CHERI Conference, Cornell University, May 2003.

Hoxby, Caroline M. "Do Immigrants Crowd Disadvantaged American Natives Out of Higher Education," in Daniel S. Hamermesh and Frank D. Bean, eds., *Help or Hindrance: The Economic Implications of Immigration for African Americans*. New York: Russell Sage Foundation, 1998.

Jacobs, Lucy Cheser and Charles B. Friedman. "Student Achievement under Foreign Teaching Associates Compared with Native Teaching Associates," *Journal of Higher Education* September/October 1988, pp. 551-563.

Johnson, George. "Estimation of the Impact of Immigration on the Distribution of Income Among Minorities and Others." In *Help or Hindrance? The Economic Implications of Immigration for African-Americans*, edited by Daniel S. Hamermesh and Frank Bean. New York: Russell Sage Press, 1998.

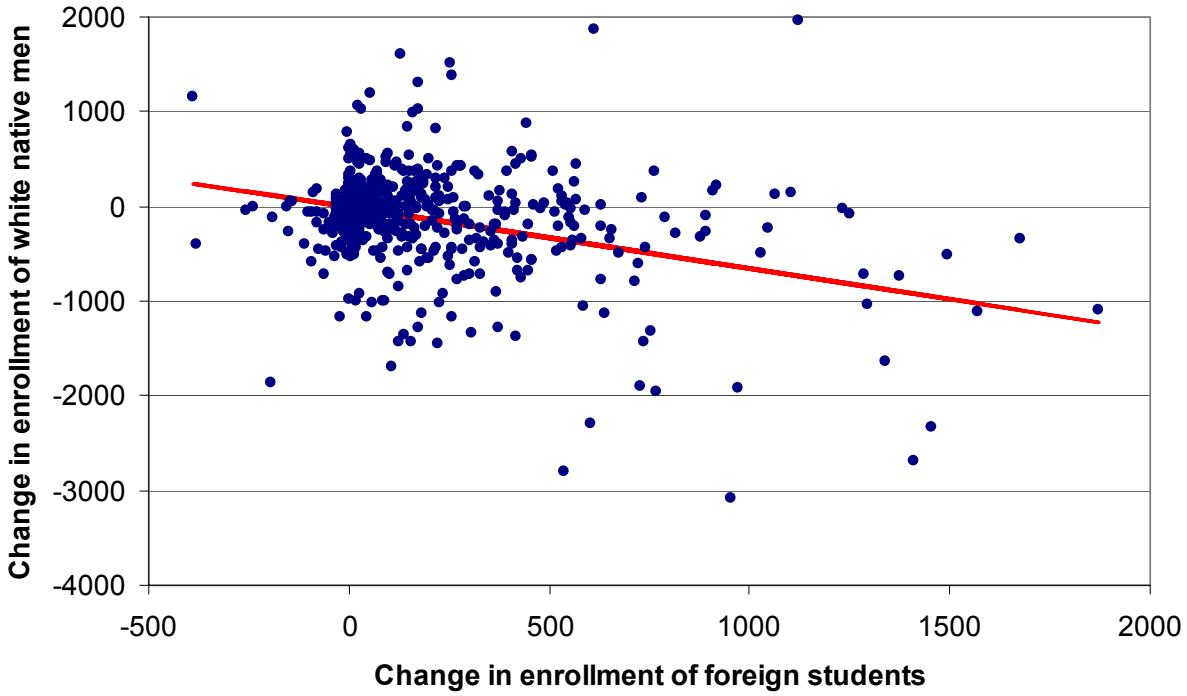
Smith, James P. and Barry Edmonston, editors. *The New Americans: Economic, Demographic, and Fiscal Effects*. Washington, DC: National Academy Press, 1997.

Stephan, Paula E. and Sharon G. Levin, "Exceptional Contributions to U.S. Science by the Foreign-Born and Foreign-Educated," *Population Research and Policy Review* **20**, 59, (2001).

U.S. Department of Education, National Center for Education Statistics *Digest of Education Statistics, 2001*. Washington, DC: 2002.

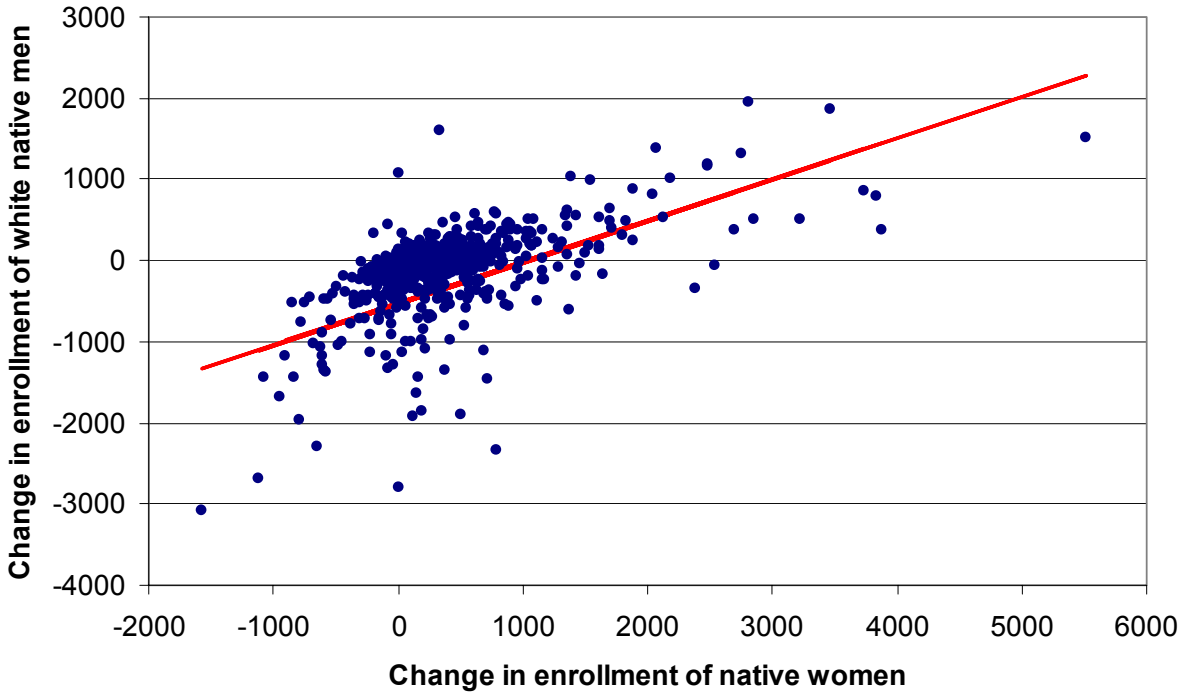
Winston, Gordon C. "Subsidies, Hierarchy and Peers: The Awkward Economics of Higher Education," *Journal of Economic Perspectives*, Winter 1999, pp. 13-36.

Figure 1. Scatter Diagram Relating Change in Enrollment of Foreign Students and White Native Men, 1978-98



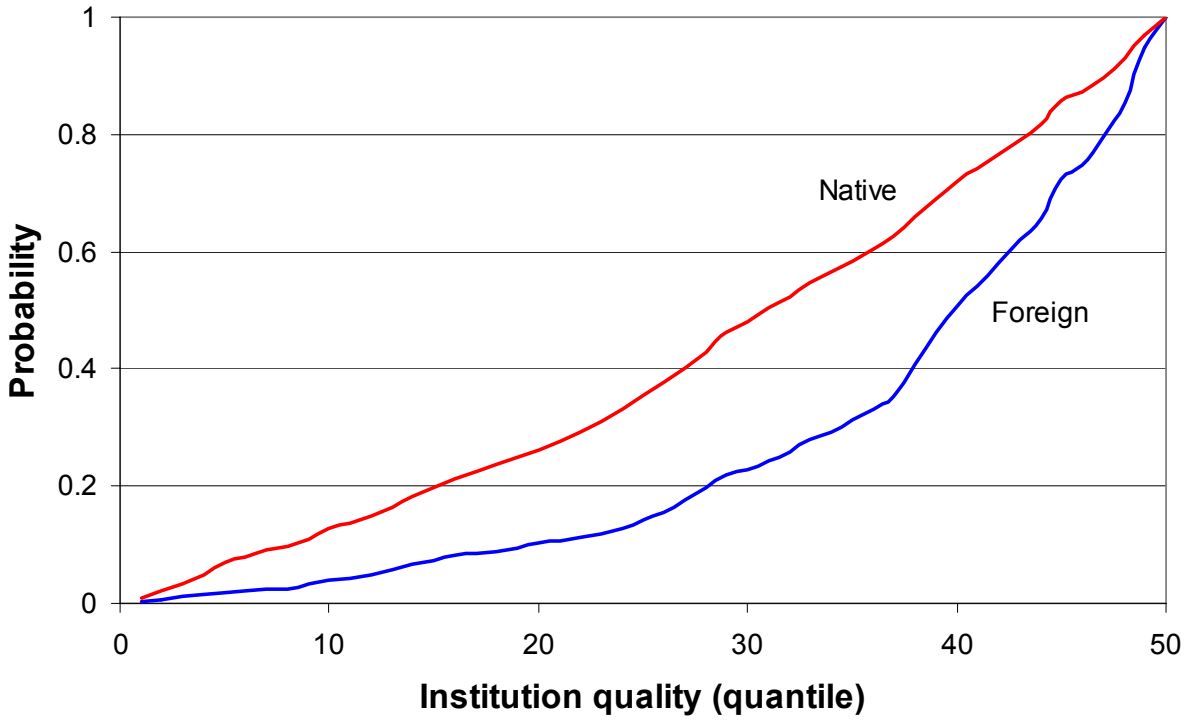
Notes: Each point in the scatter diagram indicates the 1978-98 change in foreign students and white native men for a particular university. The enrollment data for each institution are drawn from the 1978 HEGIS and the 1998 IPEDS. The regression line weighs the data by the total graduate enrollment at the university (as of 1998). The coefficient is -.649, with a standard error of .053.

Figure 2. Scatter Diagram Relating Change in Enrollment of White Native Women and White Native Men, 1978-98



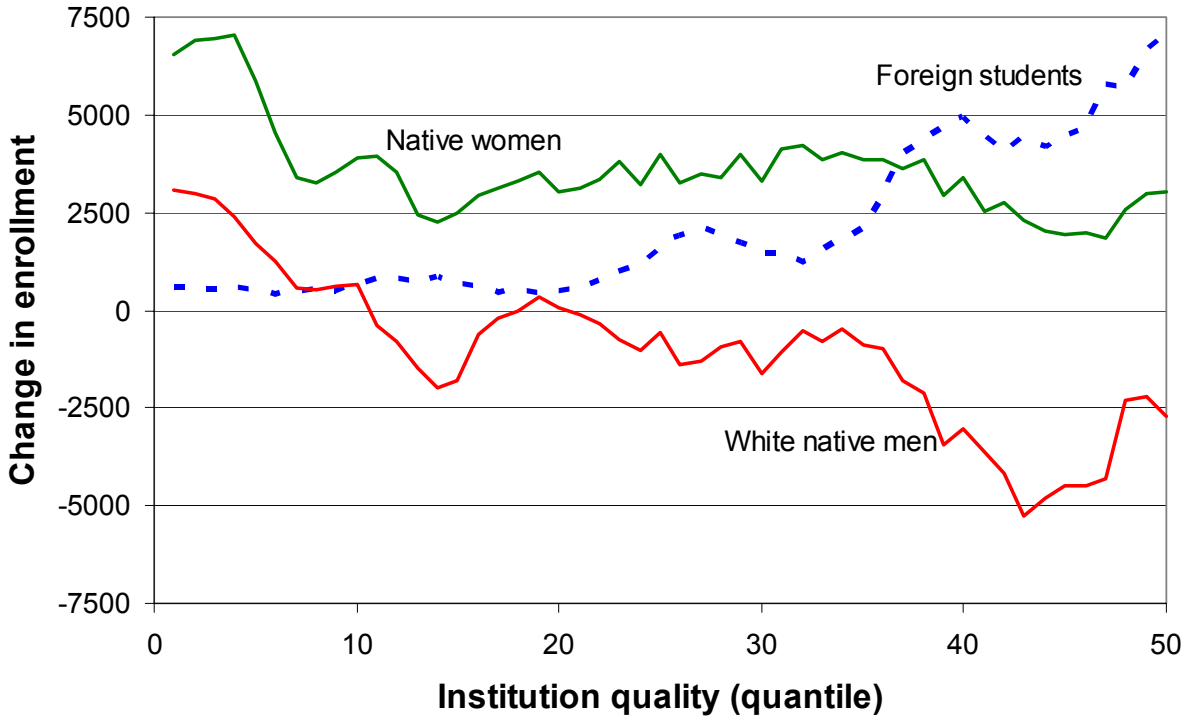
Notes: Each point in the scatter diagram indicates the 1978-98 change in foreign students and white native men for a particular university. The enrollment data for each institution are drawn from the 1978 HEGIS and the 1998 IPEDS. The regression line weighs the data by the total graduate enrollment at the university (as of 1998). The coefficient is -.649, with a standard error of .053.

Figure 3. Cumulative Enrollment Distributions for Native and Foreign Graduate Students, 1998



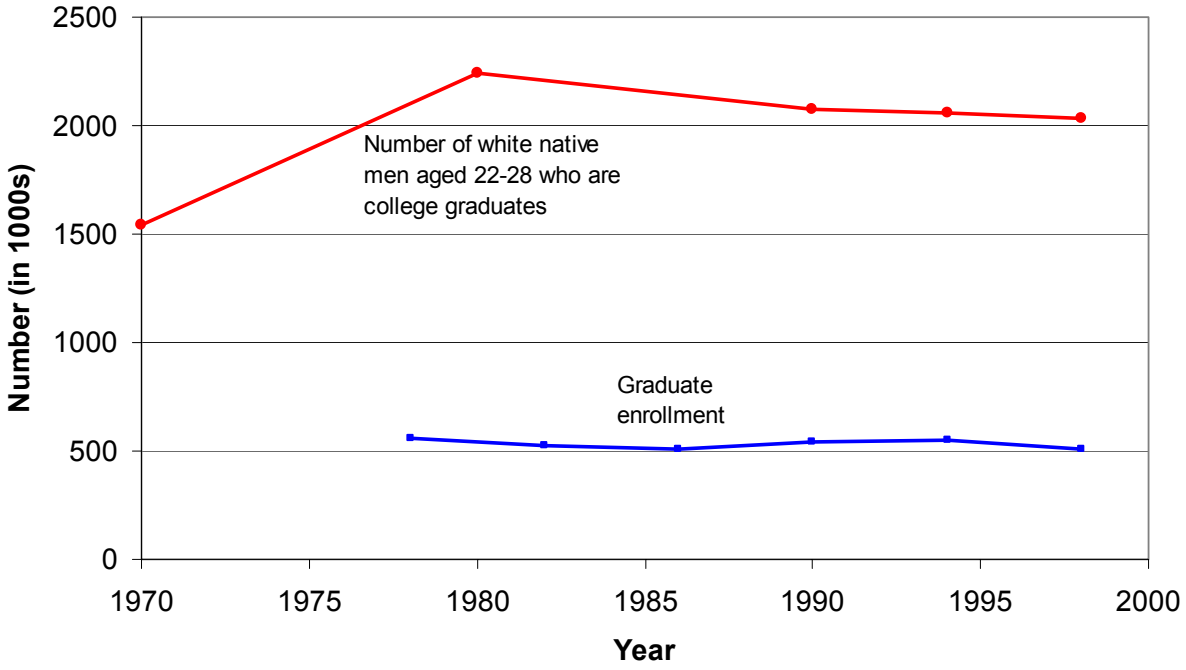
Notes: The enrollment data is drawn from the 1998 IPEDS. The quality ranking for an institution is based on the institution's per-student instructional expenditure between 1990 and 1993; see the text for more details.

Figure 4. Change in Enrollment between 1978 and 1998, by Quality of Institution



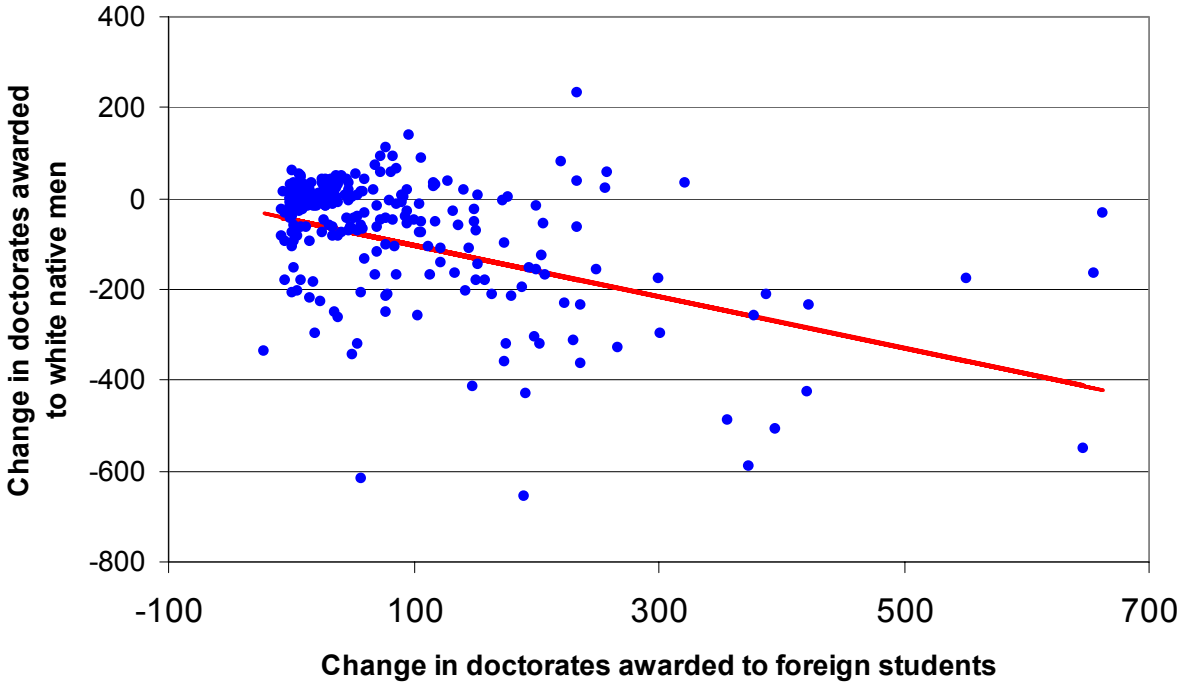
Notes: The enrollment data for each institution are drawn from the 1978 HEGIS and the 1998 IPEDS. The quality ranking for an institution is based on the institution's per-student instructional expenditure between 1990 and 1993; see the text for more details. The trend lines are drawn using a five-quantile moving average.

Figure 5. Demographic Trends and Graduate Enrollment of White Native Men



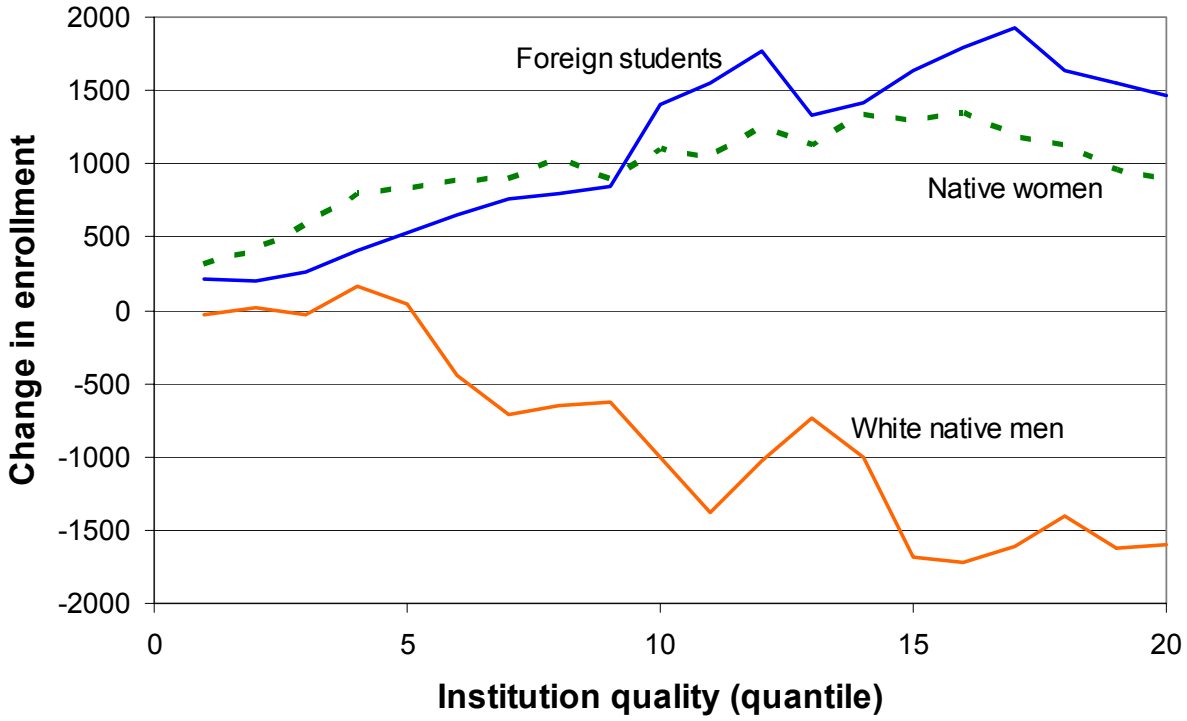
Notes: The size of the population of white native men aged 22-28 who are college graduates is calculated using the 1970, 1980 and 1990 Public Use Microdata Samples of the U.S. Census, and the 1994 and 1998 Annual Demographic Supplement of the Current Population Surveys. The total enrollment in graduate programs includes both part-time and full-time students and is calculated using data from the 1978 and 1982 HEGIS, and the 1986, 1990, 1994, and 1998 IPEDS.

Figure 6. Scatter Diagram Relating Change in Doctorates Earned by Foreign Students and White Native Men, 1975-78 to 1995-98



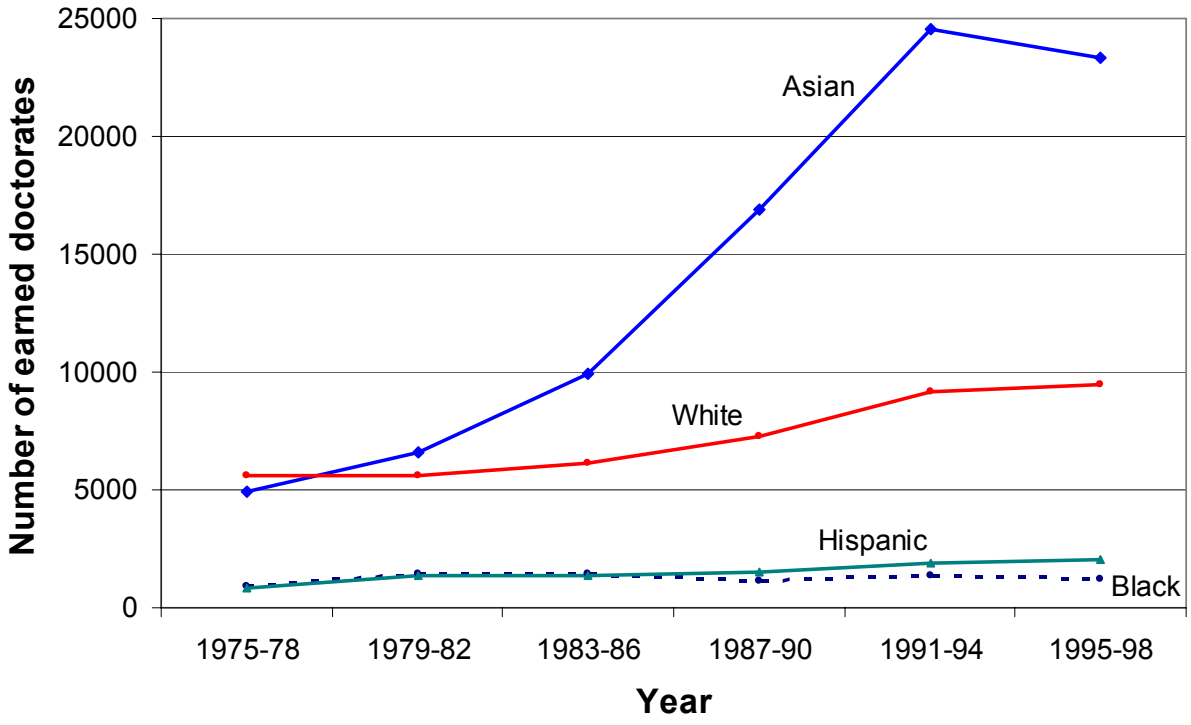
Notes: Each point in the scatter diagram indicates the change between 1975-78 and 1995-98 in the number of doctorates awarded to foreign students and white native men at a particular university. The data are drawn from the Survey of Earned Doctorates. The regression line weighs the data by the total graduate enrollment at the university (as of 1998). The coefficient is -.566, with a standard error of .059.

Figure 7. Change in the Number of Doctorates Awarded Between 1975-78 and 1995-98, by Quality of Institution



Notes: The change in the total number of doctorates awarded by an institution is calculated using the Survey of Earned Doctorates. The quality ranking for an institution is based on the institution's per-student instructional expenditure between 1990 and 1993; see the text for more details. The trend lines are drawn using a three-quantile moving average.

Figure 8. Number of Doctorates Earned by Foreign Students, by Ethnicity



Notes: The total number of doctorates awarded is calculated using the Survey of Earned Doctorates. The ethnic groups in the figure are mutually exclusive, but not exhaustive. The figure omits the data for the "other" ethnic category.

Table 1. Enrollment Trends in Graduate Programs, 1978-1998
(Number of students in 1000s)

	Year					
Group:	1978	1982	1986	1990	1994	1998
Nonresident aliens	79.4	105.0	132.4	167.3	179.5	194.3
Male	60.7	78.7	97.0	116.4	118.1	120.8
Female	18.7	26.3	35.4	50.9	61.4	73.4
All natives	1239.3	1217.3	1302.9	1418.8	1542.0	1569.6
Male	627.0	591.0	596.3	621.0	657.7	631.3
Female	612.3	626.3	706.6	797.9	884.3	938.2
Asian natives	27.5	35.0	41.7	53.2	72.6	86.2
Male	16.3	20.9	24.5	29.7	38.3	41.8
Female	11.1	14.2	17.2	23.6	34.3	44.4
Black natives	76.4	68.9	70.3	83.9	110.6	138.6
Male	29.9	26.1	25.6	29.3	37.7	44.1
Female	46.5	42.8	44.7	54.6	72.9	94.5
Hispanic natives	27.9	31.7	44.4	47.2	63.9	82.7
Male	14.4	14.8	19.9	20.6	27.0	32.4
Female	13.5	17.0	24.6	26.6	36.9	50.3
White natives	1094.0	1074.7	1101.4	1228.4	1286.8	1252.4
Male	556.0	525.5	505.2	538.8	551.4	509.3
Female	537.9	549.2	596.2	689.5	735.4	743.1

Source: The statistics are calculated using the HEGIS (pre-1982) and the IPEDS (post-1986) data files. The data do not include students enrolled in professional programs.

Table 2. Impact of Foreign Students on Native Enrollment, By Gender and Ethnicity of Native Students

	Gender of natives		
Ethnicity of native group:	Male and female	Male	Female
A. Graduate enrollment			
All natives	.046	-.198	.244
	(.279)	(.152)	(.141)
Asian natives	.232	.105	.127
	(.054)	(.025)	(.030)
Black natives	.105	.033	.071
	(.026)	(.009)	(.019)
Hispanic natives	.191	.080	.111
	(.126)	(.054)	(.073)
White natives	-.488	-.418	-.070
	(.268)	(.139)	(.145)
B. Graduate enrollment and professional schools			
All natives	.142	-.268	.410
	(.255)	(.144)	(.141)
Asian natives	.376	.179	.197
	(.090)	(.044)	(.047)
Black natives	.141	.044	.097
	(.027)	(.009)	(.019)
Hispanic natives	.196	.081	.115
	(.104)	(.045)	(.060)
White natives	-.583	-.576	-.007
	(.273)	(.145)	(.154)

Notes: Standard errors are reported in parentheses and are clustered by institution. The regressions reported in Panel A have 8,236 observations; and the regressions reported in Panel B have 8,630 observations. All regressions include a vector of fixed effects indicating the institution and a vector of fixed effects indicating the survey year.

Table 3. Impact of Foreign Students on Native Enrollment in Public and Private Institutions

	Gender of natives		
Ethnicity of native group:	Male and female	Male	Female
A. Public institutions			
All natives	.214	-.093	.307
	(.342)	(.178)	(.177)
Asian natives	.089	.043	.046
	(.033)	(.021)	(.015)
Black natives	.076	.025	.051
	(.024)	(.011)	(.015)
Hispanic natives	.238	.107	.132
	(.218)	(.093)	(.125)
White natives	-.197	-.272	.075
	(.259)	(.139)	(.135)
B. Private institutions			
All natives	-.194	-.328	.134
	(.404)	(.227)	(.208)
Asian natives	.393	.174	.219
	(.099)	(.050)	(.050)
Black natives	.133	.042	.091
	(.042)	(.015)	(.031)
Hispanic natives	.130	.046	.084
	(.040)	(.014)	(.032)
White natives	-.856	-.589	-.267
	(.428)	(.222)	(.239)

Notes: Standard errors are reported in parentheses and are clustered by institution. The regressions in Panel A have 3,103 observations, while the regressions in Panel B have 5,133 observations. All regressions include a vector of fixed effects indicating the institution and a vector of fixed effects indicating the survey year.

Table 4. Crowdout Effects of Native Women and Blacks on Graduate Enrollment of Native Men

	Specification 1	Specification 2	
Native group:	Native women	Foreign students	White native women
All native men	.654	-.362	.672
	(.045)	(.096)	(.048)
Asian men	.028	.099	.023
	(.008)	(.026)	(.007)
Black men	.048	.022	.047
	(.007)	(.009)	(.007)
Hispanic men	.102	.056	.099
	(.071)	(.032)	(.069)
White men	.469	-.539	.496
	(.063)	(.109)	(.060)

Notes: Standard errors are reported in parentheses and are clustered by institution. The regressions have 8,236 observations. All regressions include a vector of fixed effects indicating the institution and a vector of fixed effects indicating the survey year.

Table 5. Impact of Foreign Students on Native Enrollment, by Quality of Institution

	Quantile of quality distribution							
	1-10th		11th-40th		41-50th		50th	
Native group:	θ	Standard error	θ	Standard error	θ	Standard error	θ	Standard error
All natives	9.358	(3.371)	.515	(.323)	-.176	(.294)	-.466	(.558)
Men	3.911	(1.668)	.104	(.152)	-.308	(.166)	-.466	(.291)
Women	5.448	(1.745)	.411	(.192)	.132	(.153)	.000	(.268)
All Asians	.169	(.105)	.151	(.026)	.216	(.091)	.165	(.034)
Men	.097	(.041)	.079	(.018)	.088	(.043)	.051	(.023)
Women	.072	(.066)	.072	(.009)	.128	(.050)	.114	(.013)
All blacks	.377	(.170)	.121	(.030)	.117	(.038)	.149	(.041)
Men	.200	(.068)	.044	(.011)	.033	(.012)	.045	(.014)
Women	.177	(.150)	.077	(.021)	.084	(.028)	.104	(.028)
All Hispanics	8.090	(4.171)	.074	(.041)	.094	(.037)	.083	(.007)
Men	3.427	(1.805)	.034	(.015)	.033	(.011)	.027	(.004)
Women	4.663	(2.367)	.040	(.027)	.061	(.029)	.056	(.004)
All whites	.719	(1.035)	.191	(.308)	-.649	(.322)	-.882	(.488)
Men	.188	(.281)	-.038	(.140)	-.493	(.167)	-.605	(.253)
Women	.530	(.801)	.229	(.187)	-.157	(.179)	-.277	(.236)

Notes: All standard errors are clustered by institution. The regressions estimated in the bottom 10 quantiles have 1,101 observations; the regressions estimated in the middle 30 quantiles have 3,632 observations; the regressions estimated in the top 10 quantiles have 1,216 observations; and the regressions estimated in the 50th quantile have 115 observations. All regressions include a vector of fixed effects indicating the institution and a vector of fixed effects indicating the survey year.

Table 6. Trends in the Number of Doctorates Awarded, 1975-1998
(Number of earned doctorates in 1000s)

	Year					
Group:	1975-78	1979-82	1983-86	1987-90	1991-94	1995-98
Nonresident aliens	14.0	15.8	20.4	28.5	38.4	37.3
Male	12.3	13.6	17.2	23.5	30.3	28.2
Female	1.7	2.2	3.1	5.1	8.1	9.1
All natives	113.6	109.1	105.7	110.4	121.0	131.6
Male	83.4	72.1	65.2	65.4	67.9	71.0
Female	30.1	37.0	40.5	45.0	53.2	60.7
Asian natives	4.1	4.5	4.5	5.3	10.5	13.0
Male	3.3	3.4	3.2	3.6	7.0	8.1
Female	.8	1.1	1.2	1.6	3.5	4.9
Black natives	4.6	4.5	4.1	4.0	5.1	6.3
Male	2.8	2.3	1.9	1.9	2.3	2.6
Female	1.8	2.2	2.1	2.1	2.8	3.6
Hispanic natives	1.9	2.3	2.6	3.0	3.7	4.6
Male	1.3	1.4	1.4	1.6	2.0	2.4
Female	.5	.8	1.1	1.3	1.7	2.2
White natives	94.7	89.8	86.1	88.4	96.6	97.8
Male	69.6	59.3	52.7	51.6	53.7	52.5
Female	25.1	30.5	33.3	36.9	42.9	45.3

Source: The statistics are calculated using the Survey of Earned Doctorates. The ethnic categories in the native population are mutually exclusive, but not exhaustive. The number of earned doctorates is not reported for the "other" residual category.

Table 7. Impact of Foreign Students on Native Doctorates, Basic Results

	Gender of natives		
Ethnicity of natives	Male and female	Male	Female
A. All institutions			
All natives	.148	-.233	.381
	(.180)	(.120)	(.071)
Asian natives	.214	.130	.084
	(.024)	(.014)	(.011)
Black natives	-.007	-.012	.005
	(.017)	(.011)	(.008)
Hispanic natives	.057	.024	.033
	(.009)	(.004)	(.007)
White natives	.040	-.242	.282
	(.119)	(.081)	(.051)
B. Public institutions			
All natives	.181	-.206	.387
	(.204)	(.137)	(.080)
Asian natives	.190	.120	.071
	(.024)	(.015)	(.011)
Black natives	-.007	-.013	.006
	(.020)	(.013)	(.008)
Hispanic natives	.058	.024	.034
	(.011)	(.005)	(.009)
White natives	.066	-.229	.296
	(.137)	(.096)	(.053)
C. Private institutions			
All natives	-.317	-.534	.217
	(.275)	(.189)	(.132)
Asian natives	.345	.188	.157
	(.031)	(.027)	(.011)
Black natives	-.019	-.014	-.005
	(.017)	(.008)	(.011)
Hispanic natives	.053	.020	.032
	(.011)	(.007)	(.007)
White natives	-.315	-.405	.089
	(.174)	(.117)	(.111)

Notes: Standard errors are reported in parentheses and are clustered by institution. The regressions reported in Panel A have 2,113 observations; the regressions reported in Panel B have 1149 observations; and the regressions reported in Panel C have 964 observations. All regressions include a vector of fixed effects indicating the institution and a vector of fixed effects indicating the survey year.

Table 8. Impact of Foreign Students on Native Doctorates, by Field of Study

	Natives			White natives		
Field:	All	Male	Female	All	Male	Female
Agricultural sciences	.010	-.166	.177	.028	-.111	.139
	(.137)	(.176)	(.055)	(.182)	(.210)	(.044)
Biological sciences	.362	-.122	.485	.057	-.266	.323
	(.197)	(.111)	(.109)	(.130)	(.076)	(.080)
Health sciences	1.084	.070	1.014	.569	-.062	.630
	(.151)	(.099)	(.117)	(.126)	(.065)	(.120)
Engineering	.516	.403	.113	.359	.283	.076
	(.098)	(.083)	(.022)	(.078)	(.065)	(.016)
Computer science and mathematics	.213	.132	.080	.127	.059	.068
	(.100)	(.075)	(.032)	(.060)	(.050)	(.018)
Physical sciences	.136	-.124	.259	.067	-.122	.189
	(.118)	(.098)	(.041)	(.105)	(.089)	(.033)
Social sciences	-.351	-.492	.141	-.319	-.385	.066
	(.254)	(.144)	(.140)	(.231)	(.144)	(.115)
Humanities	.825	.039	.786	.618	.030	.589
	(.270)	(.151)	(.162)	(.235)	(.130)	(.152)
Education	1.992	.574	1.418	1.729	.542	1.187
	(.658)	(.401)	(.387)	(.534)	(.360)	(.281)
Professional fields	.407	.081	.326	.303	.001	.302
	(.147)	(.146)	(.086)	(.140)	(.130)	(.062)

Notes: Standard errors are reported in parentheses and are clustered by institution. The number of observations in the within-field regressions is: agricultural sciences, 482; biological sciences, 1,453; health sciences, 918; engineering, 1,045; computer science and mathematics, 1,068; physical sciences, 1,324; social sciences, 1,410; humanities, 1,210; education, 1,274; and professional fields, 1,157. All regressions include a vector of fixed effects indicating the institution and a vector of fixed effects indicating the survey year.

Table 9. Impact of Foreign Students on Doctorates, by Quality of Institution

	Quantile of quality distribution							
	1-5th		6-15th		15-20th		20th	
Native group:	θ	Standard error	θ	Standard error	θ	Standard error	θ	Standard error
All natives	1.185	(.144)	.531	(.148)	-.350	(.166)	-.451	(.504)
Men	.503	(.098)	.007	(.125)	-.478	(.111)	-.408	(.160)
Women	.682	(.062)	.524	(.057)	.128	(.070)	-.043	(.408)
All Asians	.241	(.032)	.219	(.013)	.138	(.051)	.308	(.053)
Men	.150	(.023)	.139	(.008)	.080	(.027)	.184	(.034)
Women	.091	(.010)	.080	(.008)	.058	(.026)	.125	(.025)
All blacks	.061	(.015)	.023	(.016)	-.038	(.029)	-.048	(.051)
Men	.039	(.008)	.006	(.010)	-.033	(.019)	-.025	(.022)
Women	.022	(.009)	.017	(.009)	-.005	(.011)	-.023	(.031)
All Hispanics	.173	(.042)	.063	(.013)	.033	(.012)	.038	(.036)
Men	.088	(.019)	.026	(.006)	.014	(.005)	-.006	(.022)
Women	.084	(.023)	.037	(.011)	.019	(.009)	.044	(.020)
All whites	1.041	(.093)	.256	(.130)	-.180	(.116)	-.688	(.530)
Men	.445	(.066)	-.119	(.104)	-.316	(.090)	-.469	(.215)
Women	.597	(.045)	.375	(.053)	.135	(.050)	-.218	(.336)

Notes: All standard errors are clustered by institution. The regressions estimated in the bottom 5 quantiles have 400 observations; the regressions estimated in the middle 10 quantiles have 911 observations; the regressions estimated in the top 5 quantiles have 472 observations; and the regressions estimated in the 20th quantile have 95 observations. All regressions include a vector of fixed effects indicating the institution and a vector of fixed effects indicating the survey year.

Table 10. Impact of Ethnic Background of Foreign Students on Doctorates Earned by Natives

	Ethnicity of foreign students				
Native group:	Asian	Black	Hispanic	White	Other
All Asians	.205	-.406	.267	.287	-.142
	(.037)	(.277)	(.371)	(.191)	(.221)
Men	.118	-.152	.100	.221	-.080
	(.022)	(.184)	(.217)	(.099)	(.124)
Women	.087	-.254	.167	.067	-.062
	(.018)	(.110)	(.172)	(.099)	(.108)
All blacks	-.027	.597	.122	.028	.146
	(.021)	(.171)	(.189)	(.055)	(.079)
Men	-.029	.233	.112	.022	.073
	(.013)	(.106)	(.107)	(.031)	(.054)
Women	.002	.364	.010	.007	.073
	(.010)	(.085)	(.104)	(.034)	(.040)
All Hispanics	.054	-.004	.227	.027	.007
	(.013)	(.096)	(.128)	(.062)	(.071)
Men	.026	.062	.031	.009	.019
	(.006)	(.057)	(.088)	(.031)	(.038)
Women	.028	-.066	.196	.019	-.012
	(.009)	(.056)	(.087)	(.035)	(.042)
All whites	-.337	4.419	2.190	.978	1.828
	(.164)	(1.487)	(1.304)	(.602)	(.822)
Men	-.625	2.976	1.398	.898	1.522
	(.122)	(.947)	(.915)	(.431)	(.620)
Women	.288	1.443	.792	.080	.306
	(.072)	(.731)	(.546)	(.263)	(.306)

Notes: Standard errors are reported in parentheses and are clustered by institution. The regressions have 2,113 observations. All regressions include a vector of fixed effects indicating the institution and a vector of fixed effects indicating the survey year.