

Do Foreign Doctorates Displace Native Doctorates in American Universities?

Liang Zhang

[Abstract] The last forty years have seen a significant increase in the number of doctorates awarded to foreign students and in the proportion of female doctorates in some academic fields. Using data on the number of doctorates awarded in all academic fields from 1966 to 2002, this paper examines the “crowding-out” effect and the “tipping” effect systematically. Science and engineering fields show no evidence of native doctorates being crowded out by foreign doctorates. However, outside of science and engineering, there is a strong negative correlation between the number of foreign doctorates and native male doctorates—accounted for almost entirely by the field of non-science education. Male students, especially native male students, exhibit strong “women-avoiding” behaviors in selecting academic fields of doctoral study, suggesting that native male students opt out of, instead of being crowded out, of fields with a high proportion of female doctorates.

I. Introduction

Many people believe the picture is clear. Foreign students are crowding out native students from graduate programs (especially doctoral programs) in American universities. Borjas (2004a) documented that the share of non-resident aliens enrolled in graduate programs in the United States rose from 5.5 percent in 1976 to 12.4 percent in 1999. In science and engineering (SE) fields, the increase was even more pronounced. In the 1999-2000 academic year, non-resident aliens received 38.2 percent of doctorates awarded in the physical sciences, 52.1 percent of doctorates in engineering, 26.6 percent in the life sciences, and 22.8 percent in the social sciences. Recent data show that in 2002 about 26 percent of all doctorates awarded in American universities went to temporary residents, and in SE fields more than 32 percent of doctorates were conferred on temporary residents (Hoffer et al. 2003).¹

The increase in doctorates awarded to foreign students has raised several concerns among U.S. researchers and policy makers. Doctoral education demands enormous intellectual and financial resources; thus an increase in the number of doctorates earned by foreign students limits educational opportunities for native students, unless additional financial resources can be gained by educating foreign students. This can be achieved only when the benefits (e.g., tuition revenue) outweigh the costs, a situation that is unlikely given the heavy subsidies at the doctoral level of study in both public and private institutions in the United States. For example, more than 90 percent of foreign doctorates in recent years

received various forms of financial assistance from their universities during their graduate studies (Hoffer et al. 2003).

The influx of foreign doctorates has a tremendous impact on the U.S. economy. Stephan and Levin (2001) showed that individuals making exceptional contributions to science and engineering in the United States were disproportionately drawn from the foreign born. On the other hand, the influx of these highly educated workers could also have displaced natives from some professional positions and lowered wages. Borjas (2004b) found that a 10 percentage point immigration-induced increase in the supply of doctorates lowers the wage of competing doctorates by about 3 to 4 percentage points.

One particular concern raised by the growing enrollment of foreign doctoral students is that they may contribute to the continued under-representation of minorities among the doctoral population in the U.S., either by directly replacing minority students in the admissions process or by discouraging minority students from pursuing doctoral studies because of the lowered salaries they induced. Although it is not clear that an increase in the number of doctorates awarded to foreign students hurts minorities more than it might hurt other native groups, that increase is usually an easy “scapegoat” for the continued under-representation of minorities in the doctoral population.

The increase of foreign doctorates is but one aspect of the changing pattern of doctorate production in American universities. Another is that graduate programs are increasingly becoming “feminine”; and some academic fields have already witnessed a ratcheting process toward the female. Between 1967 and 2002, the proportion of female doctorate recipients increased from 11.6 percent to 45.4 percent for all fields in American universities. In non-SE fields, female doctorates comprise the majority of degrees conferred. For example, in 2002, 67 percent of doctorate recipients in psychology, 61 percent in sociology, 60 percent in foreign languages, 66 percent in education, 58 percent in communication and librarianship, 58 percent in anthropology, and 59 percent in linguistics were female.

The gender shake-up among doctorate recipients has far-reaching social significance. On one hand, as women move into fields traditionally dominated by men, they elevate their positions in the labor market, thereby contributing to gender equality in general. On the other, as the proportion of women with

doctorates in some fields goes up, male students may avoid these fields, anticipating that wages will go down when the fields are “too female.” Furthermore, male students may find it socially stigmatizing to pursue fields of study with a preponderance of females (England et al. 2004). If this trend continues, segregation among academic fields is likely to occur, and a stable, integrated gender equilibrium will be at stake.

Somewhat surprisingly, very few studies have addressed whether more foreign doctorates have led to fewer native doctorates and why certain academic fields are becoming predominantly female. Moreover, when examined at all, these two issues are often addressed separately. This study looks at these issues in a connected way by linking findings from both areas, thus enabling us to have a more complete picture of the changing pattern of doctorate production in American universities. In particular, I ask two questions: (1) Is there a crowding-out effect of foreign doctorates on native doctorates? If so, in what fields, and is there a difference by gender? (2) Do male students exhibit “women-avoiding” behaviors in pursuing doctoral studies? If so, in what fields, and is there a difference by citizenship?

II. Models of Doctorate Production

The *crowding-out effect* is a term used loosely by researchers to attribute the shrinkage of one group to the growth of others. For example, if foreign doctorates crowd out native doctorates, it means that a decrease in the number of native doctorates is due to an increase in the number of foreign doctorates. This crowding out may take several forms. One form is clear. In the short run, the total number of doctoral students who can be educated is relatively fixed, and one additional doctorate awarded to a foreign student may translate directly into one fewer awarded to native students. Another form is less clear, in that in the long run the number of degrees earned by both foreign students and native students could be rising, but the proportion of degrees earned by native students could be decreasing. In fact, a variety of “crowding-out” effects could be defined using different benchmarks. For example, the numbers of both foreign and native doctorates could be rising, and the proportion of native doctorates might also be rising. Still, the number of native doctorates could have increased more if the number of foreign students had not increased. In essence, all types of crowding-out effects depend on what is assumed to be

neutral. To avoid ambiguity, the simplest form of crowding-out effect is used in this analysis. That is, a crowding-out effect exists if the number of doctorates awarded to native students actually falls as the number of doctorates awarded to foreign students rises.²

Doctorate recipients are often categorized according to demographic characteristics such as gender, race/ethnicity, and citizenship. Institutions have to make decisions regarding the number of students in each category to admit to their doctoral programs. Although preferences and missions may vary among institutions, a well-balanced and diversified cohort of graduates is generally a legitimate goal of doctorate production in American universities. Quality is probably the primary reason. Presumably, the average quality of doctorates in a particular category declines when the number of doctorates in that category increases. For example, if the distribution of talent is about the same for male and female students, universities may wish to produce about the same number of doctorates in these two groups, assuming their goal is to maximize the aggregated talent for a fixed number of doctorates.³

Furthermore, diversity itself may be a reasonable goal, so universities may give preference to under-represented groups. Those fields with few doctorates awarded to women may have as a priority an increase in the number of female students. Similarly, those fields with few doctorates awarded by foreign students may wish to increase the number of foreign students. With regard to both gender and ethnicity, a division occurs between the SE and non-SE fields. The former includes physical sciences, life sciences, and engineering but not social sciences.⁴ Historically, the SE fields produced a small number of female doctorates while the non-SE fields usually had a small number of foreign doctorates. For example, in the later 1960s, women with doctorates made up less than 6 percent of the population in SE fields, but over 17 percent in non-SE fields. In contrast, foreign students earning doctorates made up about 15 percent of the population in SE fields in the later 1960s, but less than 6 percent in non-SE fields.

In the above model, universities are decision-making entities, and an individual's decision has little impact on doctorate production. Needless to say, institutional decisions about the representation of different categories of doctorates are influenced by other factors, such as the current pool of applicants in each category. One factor that may contribute to the increasing share of female doctorates in some fields

is male students' unwillingness to enter fields that have a high proportion of women. Sociologists and economists have studied similar avoidance behaviors in other areas. Schelling's (1978) model of residential segregation suggested that whites' unwillingness to live in neighborhoods with a high proportion of blacks could lead neighborhoods to become all black. Similar trends were observed in other social phenomena. For example, Lieberman, Dumais, and Baumann (2000) examined the trends in unisex names, and found that as the proportion of girls with a particular unisex name increased, parents stopped giving that name to boys. Likewise, England et al. (2004) invoked the tipping model to study doctorate production in American universities. Their results suggested that the higher the proportion of females receiving degrees in a field in a given year, the smaller the number of males who enter the field 4-7 years later.

However, native and foreign male students could have quite different patterns of "woman-avoiding" behavior. For example, because native male students have a better idea of the gender composition in a particular field in the U.S. through observing the gender of their junior professors, teaching assistants, and graduate students, it may be easier for them to exhibit "woman-avoiding" behaviors than for foreign male students to do so. On the monetary front, the relatively lower wage in fields with a high proportion of women might dampen the enthusiasm of native male students to pursue doctorates in those fields more than it might for foreign male students, because the relatively lower wage might still be attractive to them when compared to the wage in their home countries. In fact, aggregate level data suggest that the number of native and foreign male doctorates produced in American universities exhibited quite different trends over the past forty years or so (see Figure 1). For example, a decrease in the total number of doctorates occurred only for native males but not for foreign males. It seems necessary to separate these two groups of male doctorates if we are to understand the changing gender composition of doctorate production in American universities.

Further, there are important differences among fields of study. In SE fields, the number of doctorates awarded to females is about half that awarded to males, while in non-SE fields, female doctorates outnumber male doctorates, and in some fields female doctorates have reached a substantial

majority of all doctorates. Thus it is reasonable to expect that the “tipping effect” is more pronounced in non-SE fields than in SE fields. Practically speaking, even if a negative correlation is observed between the proportion of women receiving doctoral degrees in a given year and the number of men receiving doctorates several years later in SE fields, these fields are not tipping toward the female; instead, they are moving toward gender equilibrium.

III. Data and Methods

This analysis uses data drawn from the *Survey of Earned Doctorates* (SED), which provides a population census of all doctorate recipients from American universities each year. The National Science Foundation makes the data publicly available through the Webcaspar. I extract data on the number of doctorates in all fields of study from 1966 to 2002, a span of 37 years. The Webcaspar classifies doctorates into 49 fields. For each field, the SED reports the number of doctorates by gender, citizenship, and race/ethnicity. I treat U.S. citizens and permanent residents as one category termed native doctorates, and temporary residents as another category termed foreign doctorates. After aggregating small categories appropriately, I obtain the number of doctorates in various groups, such as total female, total male, native male, and minority doctorates. Further, I calculate the share of a particular subcategory within a larger category, such as the share of female doctorates, the share of native female doctorates, and the share of foreign female doctorates.

The National Center for Education Statistics has data on the number of baccalaureate recipients from American universities each year. The Webcaspar also reports these numbers in same fields as in the SED. I use the number of college graduates to control for the year-to-year fluctuation in the number of doctorates due to the change in the flow of college graduates. Finally, the decision of foreign students to pursue doctoral degrees might be influenced by the prospect of remaining in U.S. after graduation. Since 1967 the National Research Council has published series of annual reports based on the SED, which asks doctorate recipients their post-graduation plans. Among those who have definite commitments after graduation, the proportion of foreign doctorates who will remain in U.S. is reported. Although this information is available only since 1988 in the published annual report, these data are probably sufficient

because the tipping effect is most likely to happen in later years when the proportion of female doctorates has reached a certain level.

To test the crowding-out effect of one group on another, the number of doctorates in the two groups in the same year is used. For example, the crowding-out effect of foreign doctorates on native doctorates is estimated by a fixed effect model where the number of native doctorates is the left-hand side variable and the number of foreign doctorates is the right-hand side variables. The model also controls for field fixed effect, year fixed effect, and other covariates such as the number of college graduates for the doctoral cohort. Because the field classification is somewhat arbitrary and there are substantial variations in the size of fields, it is necessary to weigh the analysis by the total number of doctorates in each field.

In estimating the tipping effect, i.e., the impact of the proportion of female doctorates on the number of male doctorates, it is important to “match up” the share variables with the correct doctoral cohort. The rationale is that male students form their idea of the gender composition of a field from observing the gender of their junior professors, teaching assistants, and graduate students. The length of one doctoral cohort would probably be a good choice of the length of lags. The SED measures time to degree in two ways: (1) the total time elapsed from the completion of baccalaureate to the completion of doctorate, (2) the total time spent in graduate school to complete the doctoral degree. Typically, the former is about 2 to 3 years longer than the latter. Both measures of time to degree vary over time and by fields of study. The length of lags for the proportion of female doctorates is determined by the median time to degree when enrolled in graduate school, because that is the actual time of doctoral study. Hoffer et al. (2003) calculated that the median duration of graduate study has increased over the years, from 6.2 years in 1977 to about 7.5 years recently. Graduate school time to degree is shortest in the physical sciences (6.8 years) and engineering (6.7 years) and longest in the humanities (9.0 years), as reported for the 2002 cohort of doctorate recipients. To account for the fact that male students observe the gender composition of several doctoral cohorts (such as junior professors and graduate teaching assistants) and also to avoid large year-to-year fluctuations in small fields, I average the proportion of females in a field 5-8 years before the year when the cohort in question receives doctorates. Hoffer et al. (2003) also

calculated that the median time to degree since completion of the baccalaureate has increased from 8.9 years in 1977 to 10.6 years in 1997. As a result, the number of students earning baccalaureate degrees in a particular field 9 years earlier is used to control for the available “pipeline” of students with an undergraduate major in the field. The last variable to be matched up is the proportion of foreign doctorates remaining in the U.S. after graduation. Because on average foreign students spend about half a year less in graduate school than native students, this variable is lagged for 6 years

IV. Main Results

As a baseline specification, I first estimate the crowding-out effect of foreign doctorates on native doctorates. Because the crowding-out effect could be quite different in different types of fields, it is estimated for SE fields, non-SE fields, non-SE fields except for non-science education, and non-science education. Non-science education deserves special attention because the number of doctorates awarded in this field account for one-sixth of doctorates in all fields and about one-third of doctorates in non-SE fields. As a result, it is possible that the regression results for non-SE fields are driven mainly by non-science education. Results indicate that an additional foreign doctorate recipient, at the margin, is associated with about one (1.03) additional native doctorate recipient in SE fields. Estimating the effect of foreign male and foreign female doctorates separately gives similar results. For example, results show that an additional foreign male doctorate is associated with 0.65 additional native doctorates. The estimated effect of foreign female doctorates is much larger at 1.54.

While the crowding-out effect of foreign doctorates on native doctorates seems non-existent in SE fields, the picture is quite different in non-SE fields. Regression estimates show that in the aggregate, an additional foreign doctorate recipient, at the margin, is associated with about 1.17 fewer native doctorate recipients in non-SE fields. Estimating the effect of foreign male and foreign female doctorates separately indicates that they might have quite a different impact on the production of native doctorates. For example, an additional foreign male doctorate recipient is associated with about 1.11 more native doctorate recipients, while an additional foreign female doctorate is associated with 4.78 fewer native doctorates. These results suggest that, taken as a group, foreign doctorates might have crowded out native

doctorates in non-SE fields. Estimating the model separately for non-science education and other non-SE fields shows that the field of non-science education drives much of the negative correlation between the number of native and foreign doctorates. Leaving out non-science education greatly reduces the magnitude of the negative association between the number of native and foreign doctorates in non-SE fields.

The aggregate results, however, may disguise a great deal of dispersion within the native population. Indeed, much concern focuses on certain categories of the native population, such as male (especially white male) and minority groups. Because in both SE and non-SE fields the number of native female doctorates has increased over the years, excluding female doctorates from the native population would significantly decrease the estimated coefficient of foreign doctorates on native doctorates. In SE fields, an additional foreign doctorate recipient, at the margin, is associated with about 0.1 additional native male doctorate recipients. And in non-SE fields, an additional foreign doctorate is associated with almost 2 fewer native male doctorates.

Again, non-science education is the main driver of the large negative correlation between foreign and native doctorates in non-SE fields. In the field of non-science education, each additional foreign doctorate is associated with 9 fewer native male doctorates. This seemingly large “crowding-out” effect certainly needs further explanation and interpretation. The number of doctorates awarded in non-science education makes up about one-third of the total doctorates in non-SE fields. Since the early 1970s, the number of female doctorates (both foreign and native) has increased while the number of native male doctorates has decreased. Despite its 10-fold increase in number (from 26 in 1966 to 273 in 2002), foreign female doctorates still represent a very small proportion (less than 5 percent) of the total number of doctorates awarded in non-science education in recent years. Incidentally, the number of native male doctorates in this field decreased from over 4,000 in early 1970s to about 1,700 in recent years. As a result, a large negative correlation between foreign doctorates and native doctorates is observed.

Concerns about the crowding-out effect are often targeted to specific native groups, such as white males and minorities. Because white male doctorates make up the majority of the native male population,

the estimation of the crowding-out effect on white males is similar to that on all native males. One particular concern about the growing number of foreign doctorates is that they might cause the continued under-representation of minorities among the doctoral population. To test whether foreign students replace minority students in doctorate production, I examine the association between the numbers of foreign and minority doctorates. In the aggregate, there is a positive association between the number of foreign doctorates and the number of minority doctorates in both fields.

Several extensions of the above model are considered. First, it is possible that the year-to-year fluctuation in doctorate production might disguise the crowding-out effect of foreign doctorates on native doctorates. A small crowding-out effect each year could accumulate into a large effect over time. To check the robustness of the above analysis, the model is re-estimated using the moving averages of the number of doctorates awarded in each field over a certain number of years. The results turn out to be quite similar. Different lengths of moving averages are also tested, and the results are quite consistent.

Second, in all models estimated in this analysis, year dummies are included to account for time-specific factors that affect doctorate production. However, it is possible that these time-specific effects contain some crowding-out effects. To check for this possibility, year dummies are dropped from the fixed effect model, and the model is re-estimated for different groups of native doctorates. Results suggest that excluding time-specific effects does not change the results much, although most estimates decrease slightly.

The third extension of the model excludes observations from recent years. Because the number of doctorates in some categories (such as native male and foreign male categories) has stabilized since the early 1990s, it is probable that the crowding out occurred before then. Thus the model is estimated using observations before 1990. In SE fields, it seems that foreign doctorates crowded out both native males and white native male doctorates with coefficients of -0.54 and -0.50 ; however, when the number of native female doctorates is included in the model, these negative coefficients reduce to -0.02 and -0.05 respectively and both are insignificant. In non-SE fields without non-science education, there is no evidence of a crowding-out effect either.

The final extension is the possibility of the existence of crowding-out effect at certain institutions. For example, it is possible that foreign doctorates do not crowd out native doctorates in general, but this crowding-out effect may exist in high-quality institutions. In other words, native students could be pushed out of high-quality institutions into lesser institutions because of increased competition at those high-quality institutions. To examine the crowding-out effect at institution level, however, is tricky. Assuming that the number of doctorates produced each year by an institution is fixed, it follows mechanically a negative one coefficient between the number of native doctorates and the number of foreign doctorates. Another possibility is that students' moving from one institution to another institution of similar quality could also create spurious crowding-out effect when an institution-specific crowding-out effect is examined.

A straightforward way is to examine the aggregate level of doctorate production at institutions of similar quality. If it is the case that foreign doctorates have been pushed out of high-quality programs into lesser programs, we may find that the growth of foreign doctorates is more pronounced at high-quality institutions than at other institutions. To assign a quality ranking to an institution, I used the data on total academic research and development expenditures in 2002 reported by the National Science Foundation. In recent years, the top 25 institutions produced approximately a quarter of all doctorates, and the top 60 produced near a half of all doctorates.

Comparing the growth of foreign doctorates across institutions does not reveal a disproportional increase of foreign doctorates in top programs. For example, in the SE fields, the proportion of foreign doctorates increased from approximately 15% to 38%, while in the top 25 institutions, this proportion increased from 18% to 34%, and in the top 50 institutions, from 17% to 36%. The increase in the proportion of foreign doctorates is driven by the increasing number of foreign doctorates but not by the decreasing number of native doctorates. Clearly, the growth of foreign doctorates at high-quality institutions is not faster than at other institutions. If anything, the growth is slower at high-quality institutions. In the non-SE fields, the proportion of foreign doctorates increased from approximately 6% to 15%, while in the top 25 institutions, this proportion increased from 8% to 23%, and in the top 50

institutions, from 7% to 21%. The relatively faster growth of foreign doctorates in high-ranking institutions is mainly driven by the disproportionate decrease of native males in certain non-SE fields such as Education. For example, in late 1960s and early 1970s, the top 25 institutions produced about a quarter of all Education doctorates, while in recent years, these institutions produced less than one-eighth of all education doctorates.

The tipping effect models answer the question whether men avoid fields when those fields get “too female.” Regression estimates suggests a negative effect of a field’s proportion of female doctorates on the number of male doctorates in that field 5 to 8 years later. On average, a one percentage point increase in the proportion of female doctorates (i.e., an increase of about 25 female doctorates) in a field leads to 17.76 fewer male doctorates awarded in that field 5 to 8 years later. Pooling all fields together disguises a great deal of difference between SE and non-SE fields, especially when the proportion of female doctorates in these two fields generally falls into two different ranges. As expected, in SE fields, an increase in the proportion of female doctorates does not appear to deter men’s entry into these fields. In contrast, in non-SE fields, there is a large and significant negative effect of a field’s proportion of female doctorates on the number of male doctorates awarded in that field 5 to 8 years later. Meanwhile, if a higher proportion of female doctorates in a field lowers the salary in that field, women may also exhibit “women-avoiding” behavior. Indeed, similar results are shown that an increase in the proportion of female doctorates in SE fields does not appear to deter women’s entry into those fields, while an increase in non-SE fields does appear to lead to avoidance. Excluding the field of non-science education yields similar results.

If both male and female doctorates exhibit “women-avoiding” behaviors, then how does one explain the growing proportion of female doctorates in most of the non-SE fields? One possibility is that male and female doctorates might have different thresholds for engendering the avoidance response. Nonlinear functional forms seem appropriate for estimating the threshold of female doctorates that brings on the tipping effect. When the quadratic terms of the proportion of female doctorates are added to the base model, a concave functional form (with a positive linear term and a negative quadratic term) is

revealed; however, the reflection points of the male and female equations are both around 50% (50.4% for the male equation and 52.6% for the female equation). That is, both men and women start to avoid fields when female doctorates constitute the majority.

Another possible explanation for the increasing share of female doctorates in non-SE fields could be the growing number of women earning baccalaureates in non-SE fields coupled with an increasing propensity of these women to pursue doctoral degrees in these fields. For example, in non-SE fields, the share of female college graduates was slightly less than 50% in the late 1960s and early 1970s. In recent years, the share of female college graduates has increased to more than 58%.⁵ In some fields, such as non-science education, females account for about three-quarters of the college graduates. Consequently, the growing proportion of female college graduates in non-SE fields could lead to a high proportion of female doctorates. However, female students' "women-avoiding" behavior may keep these fields from tipping toward all female. Indeed, when the number of college graduates is dropped from the female equation, the negative effect of the proportion of female doctorates on the number of female doctorates 5 to 8 years later is eliminated. In contrast, when the number of college graduates is dropped from the male equation, the tipping effect is reduced to half in magnitude but is still marginally significant at the 0.1 level. These results suggest that although both male and female students exhibit "women avoiding" behaviors in pursuing doctoral studies, the faster growth in numbers of female college graduates in non-SE fields drives up the proportion of female doctorates in these fields.

Finally, to test whether native male and foreign male students have different behaviors, I estimate the model for each category of doctorates. In the aggregate native male doctorates avoid fields with a high proportion of both native female and foreign female doctorates. In contrast, foreign male doctorates seem to avoid fields with a high proportion of foreign female doctorates, but not fields with a high proportion of native female doctorates.

V. Discussion and Conclusion

Do foreign doctorates crowd out native doctorates? It is unlikely. In SE fields, there is no evidence of a negative association between the number of foreign doctorates and the number of native ones. In fact, each additional foreign doctorate recipient, on average, is associated with about one more native doctorate. Much of the growth in the native population has been fueled by females. However, even after excluding female doctorates from the native population, no evidence of a negative association between the number of foreign doctorates and the number of native male doctorates is observed. Moreover, there is no evidence of foreign doctorates crowding out specific groups of the native population, such as white males and minorities, who are often regarded as primary victims of the growing number of foreign doctorates.

In non-SE fields, the picture is different, however. In the aggregate, an additional foreign doctorate recipient, at the margin, is associated with about 1.17 fewer native doctorate recipients. This negative association is largely driven by the negative association between foreign female doctorates and native doctorates. However, one particular field—non-science education—is solely responsible for these negative correlations. Over the years, in the field of non-science education, the number of native male doctorates has dropped sharply, and the number of doctorates in other categories (native female, foreign male, and foreign female) has risen modestly. As a result, a large negative correlation between foreign doctorates and native doctorates is observed.

When all fields are aggregated and the large negative association between foreign doctorates and native doctorates in the field of non-science education is mediated by other fields, it is tempting to interpret the mitigated negative association as a crowding-out effect. Nonetheless, this analysis shows no evidence of a crowding-out effect on native doctorates as a whole in non-SE fields after excluding non-science education. Although there is some evidence of a small negative association between foreign doctorates and native male doctorates in non-SE fields even after excluding non-science education, the effect is rather small considering the relatively small increase in the number of foreign doctorates in these fields.

Is there any tipping toward all female in some fields? Again, it seems unlikely. In most SE fields, the proportion of female doctorates is relatively low; specifically, it has not reached the 50% tipping point that engenders the “women-avoiding” behaviors apparent in non-SE fields. As a result, the tipping effect is not observed in SE fields for either male or female groups. In non-SE fields, both male and female groups exhibit “women-avoiding” behaviors. In particular, when the proportion of female doctorates reaches 50% in a given field, both men and women avoid it. Because of these two countervailing forces, the feminization of some non-SE fields has largely been driven by the growing number of female college graduates in these fields. In recent years, especially since the early 1990s, however, the share of female college graduates in “feminine fields” has started to stabilize.⁶ When these cohorts earn doctoral degrees, it is unlikely that these fields will be tipping toward all female. Further research should probably focus on the determinants of undergraduate major choice decisions because in the final analysis it is the “pipeline” of students that matters.

The “women-avoiding” behavior of male students, especially native male students, is very suggestive for the interpretation of the large negative association between native male doctorates and foreign female doctorates in the field of non-science education. If native males indeed have avoided “feminine” fields, then it is difficult to make the case that it is foreign female students who have crowded out native males. The “women-avoiding” behavior suggests that native male students have opted out instead of having been crowded out of fields with a high proportion of female doctorates.

One finding that has important policy implications is the impact of the proportion of foreign doctorates staying in the U.S. after graduation on the number of native doctorates. Results suggest that in SE fields, the higher proportion of foreign doctorates remaining in the U.S. after graduation does not seem to negatively affect the number of native students pursuing doctoral studies in those fields, probably because most of the foreign doctorates continue to conduct their research as post-doctorates and do not compete in the same labor market with native doctorates. In contrast, because post-doctoral work is less common in non-SE fields, foreign doctorates’ staying in the U.S. after graduation does seem to affect

native students' decisions to pursue doctoral studies, although the effect is small and not significant in most cases.

The prospect of remaining in the U.S. after graduation clearly affects the number of foreign student pursuing doctoral degrees in American universities. The effect is largest in SE fields where the majority of foreign doctorates continue to work as post-doctorates with relatively low wages. Although there is some evidence that an increasing supply of foreign doctorates lowers the wages of competing workers, it is the foreign doctorates themselves who bear the brunt of the wage reduction (Borjas 2004b).

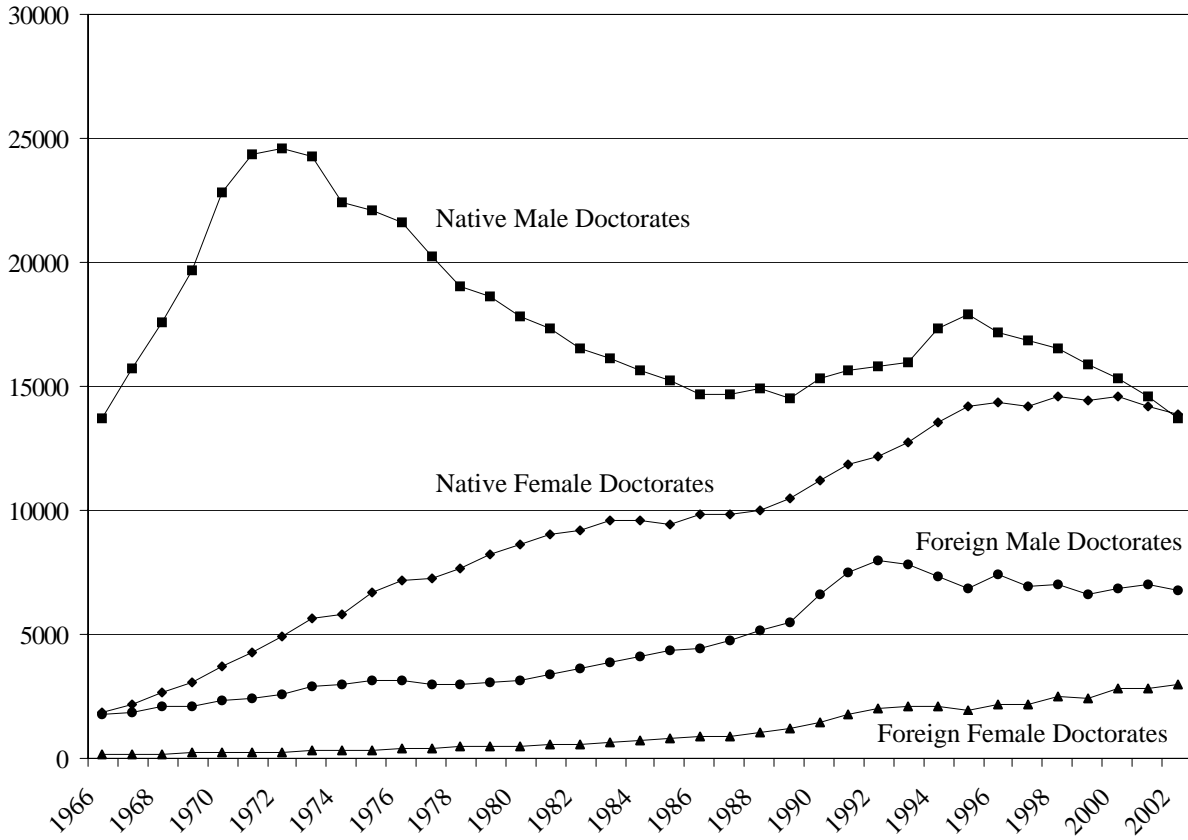
If the United States wants to attract more foreign talent, immigration policies should encourage foreign doctorates to stay in the U.S. after completing their doctoral studies. Recent stringent visa and immigration policies have significantly reduced applications from foreign students (not necessarily enrollments though). A recent survey by the Council of Graduate Schools indicated that more than 90 percent of U.S. institutions saw a drop in foreign applications for fall 2004. The drop in applications crossed all fields of study, with an 80 percent plunge in engineering and a 65 percent decrease in the physical sciences. Even worse, there was a significant drop in foreign applications to take the GRE. For example, applications from China and India were reduced by 50 and 37 percent respectively. If this trend continues, the number of foreign doctorates is bound to decrease in the years ahead. While this reduction will presumably have certain benefits for American students in the short run, such as more educational resources and probably higher wages, it will inevitably harm this nation's leadership in science in the long run.

References:

- Bellas, M. L. 1992. Comparable worth in academia: The effects on faculty salaries of the sex composition and labor market conditions of academic disciplines, *American Sociological Review*, 59(6): 807-821.
- Borjas, G. J. 2004a. Do foreign students crowd out native students from graduate programs? NBER working paper 10349.
- Borjas, G. J. 2004b. Immigration in high-skill labor market: the impact of foreign students on the earnings of doctorates. Paper presented at the conference of Science and Engineering Workforce Project at NBER, May 2004. Available online: <http://www.nber.org/~sewp>.
- Ehrenberg, R. G., and D. R. Sherman. 1984. Optimal financial aid policies for a selective university, *Journal of Human Resources*, 19(2): 202-230.
- England, P., P. Allison, S. Li, N. Mark, J. Thompson, M. Budig, and H. Sun. 2004. Why are some academic fields tipping toward female? The sex composition of U.S. fields of doctoral degree receipt, 1971-1998. Northwestern University Institute for Policy Research working paper, WP-03-12.
- Hoffer, T. B., S. Sederstrom, L. Selfa, V. Welch, M. Hess, S. Brown, S. Reyes, K. Webber, I. Guzman-Barron. 2003. *Doctorate Recipients from United States Universities: Summary Report 2002*. Chicago: National Opinion Research Center. (The report gives the results of data collected in the Survey of Earned Doctorates, conducted for six federal agencies, NSF, NIH, USED, NEH, USDA, and NASA by NORC.)
- Lieberson, S., S. Dumais, and S. Baumann (2000). The instability of androgynous names: The symbolic maintenance of gender boundaries, *American Journal of Sociology*, 105(5): 1249-1287.
- Schelling, T. C. 1978. *Micromotives and Macrobehavior*. New York: Norton & Company.
- Stephan, P. E., and S. G. Levin (2001). Exceptional contributions to U.S. science by the foreign-born and foreign-educated, *Population Research and Policy Review*, 20(1-2): 59-79.

Figure 1

Number of Doctorates Granted in the U.S., 1966-2002



¹ Hoffer et al. (2003) include the social sciences in science and engineering fields. Excluding the social sciences would increase the proportion of doctorates awarded to foreign students in science and engineering fields to 38 percent. For simplicity, in this study I call temporary resident students foreign students, and I call U.S. citizens and permanent resident students native students.

² A similar definition of crowding-out effect was used in Borjas (2004a). It is noteworthy that the term “crowding-out” in this study does not necessarily suggest a causal relation. In particular, I use the term to refer to a negative correlation between the number of native doctorates and the number of foreign doctorates. A negative correlation might be consistent with other mechanisms than the casual crowding out. However, the non-existence of a negative correlation between the number of foreign doctorates and the number of native doctorates is an evidence of no causal crowding out between the two groups.

³ A similar argument was made in Ehrenberg and Sherman (1984) in establishing a model of optimal financial aid and admissions policies for a selective university.

⁴ This classification is slightly different from that used in *Survey of Earned Doctorates* where the social sciences are classified in the broad category of the SE fields. For this analysis, the social sciences are similar to the non-SE fields in term of the proportion of female and foreign doctorates.

⁵ Data source: National Center for Education Statistics. The numbers of college graduates in non-SE fields was around 200,000 for both males and females in the late 1960s and early 1970s, and in recent years the numbers rose to 360,000 and 530,000 respectively. These non-SE fields include the social sciences.

⁶ Data source: National Center for Education Statistics. The share of female college graduates in non-SE fields overall has increased slowly during the 1990s. And in fields with a high proportion of female college graduates, their share has started to stabilize. In fact, in fields such as education and sociology, there has been a slight decrease in the share of female college graduates in recent years.