The Importance of Foreign Ph.D. Students to U.S. Science

Grant Black and Paula Stephan

Andrew Young School of Policy Studies
Georgia State University

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Section I: Introduction

During the past 20 years, science and engineering Ph.D. programs in the United States have become increasingly populated with and dependent on foreign students. Fueled by the large increase in non-citizen students, Ph.D. programs grew by 61.7% during the period 1981-1999. If U.S. Ph.D. programs had growth at the citizen-doctorates rate instead, they would have increased by only 26.3%.

The objective of this paper is three-fold: (1) to documents these trends, examining them by field and by country of origin; (2) to explore how the increase in the foreign-born Ph.D. population relates to the selectivity of the institution; (3) to examine factors affecting the rate at which foreign-born Ph.D. recipients on temporary visas stay in the U.S. The third point is of particular interest since it impacts the composition of the workforce.

Data for the study come from the Survey of Earned Doctorates (SED), administered by Science Resources Statistics of the National Science Foundation. The survey is a census of all doctoral recipients in the United States and has a response rate in excess of 98 percent.[1] We restrict our study to individuals in 16 fields of science and engineering, purposely excluding those trained in the humanities as well as the social sciences, economics/business and psychology. Unless noted, our focus is on those who hold a temporary visa at the time of receipt of the degree.

Section II: Trends

During the period 1981-1999, temporary residents accounted for more than 50 percent of the growth in Ph.D. production in the United States. Permanent residents

[1] See www.nsf.gov/sbe/srs/ssed/start.htm

provided for another 10 percent. Growth was especially strong during the first twelve years of the period, declined somewhat during the early 1990s, but has increased recently.

Figure 1 documents the dramatic increase in the number of Ph.D. recipients holding temporary visas during the period 1981-1992, followed by a decline during the next seven years. In 1981 fewer than 2,500 Ph.D. recipients in S&E held temporary visas (20 percent of all those receiving Ph.D.s in S&E), by 1992 the number stood at close to 7,000 (38.4 percent of all doctoral degrees awarded in S&E that year). By 1999 the number had decreased by approximately 1,000, with temporary-visa recipients receiving slightly more than 32 percent of all Ph.D.s awarded in S&E that year. Part of the decline in the early-to-mid 1990s reflects the passage of the Chinese Student Protection Act that permitted Chinese nationals temporarily residing in the U.S. to switch to permanent resident status. Part of the decline is also related to a statistical artifact. Beginning in 1997 the SED changed its survey procedures and there was a considerable increase in the number of doctorate recipients with "unknown" citizenship status (see Figure 1).

The growth in temporary residents has been especially dramatic in the fields of the biological and agricultural sciences and math and computer sciences. In the biological and agricultural sciences the percent of temporary residents receiving Ph.D.s more than doubled during the period 1981-1992, going from approximately 13 percent to almost 28 percent. It then fell slightly, to approximately 26 percent by 1999. In math and computer sciences the percent increased from 23.5 percent in 1981 to 46 percent in 1991 and stood at 39 percent in 1999. The change in composition has been less dramatic in engineering but the proportion of doctorate recipients who are temporary residents in

this field is substantial, hitting a high of 50.5 percent in 1991 and closing the decade at 39.6 percent.

Country of Origin. The country of citizenship of doctorate recipients with temporary visas for the decade of the 1990s is indicated on the map of Figure 2.[2] Particularly striking is the large concentration of recipients from Asia, with 60 percent coming from four countries: the People's Republic of China (21.0%); Taiwan (13.7%); India (12.2%); and South Korea (11.1%).[3] Equally striking is the fact that the next six most frequent countries are geographically dispersed (Canada, Brazil, Turkey, Greece, Germany and Mexico). Moreover, recipients from these six countries collectively make up less than 11 percent of doctoral recipients with temporary visas. Indeed, the distribution is so highly skewed that no countries fall in the range of 3 percent to 11 percent.

After the events of September 11, the State Department announced that it would impose more rigorous screening on men seeking visas from specific countries. As of this writing, there are 26 countries on the U.S. State Department watch list. Table 1 provides the number of temporary residents from these countries who received Ph.D.s in the U.S. during the 1990s. The 7,110 degrees represent 11 percent of all degrees given during the period to temporary residents and 3.6 percent of all degrees awarded. The largest number of degrees was awarded in engineering.

Much of the concern with regard to the security risks associated with Ph.D. training focuses on sensitive fields. To inform this discussion, Table 1 provides counts

[2] Country of citizenship is not reported for 1.5% of the temporary residents receiving degrees during the decade.
[3] In terms of population, China and India rank first and second, while South Korea ranks 25th and Taiwan ranks 42nd.

concerning training in "sensitive" fields, defined to include nuclear and organic chemistry, chemical and nuclear engineering, bacteriology, biochemistry, biotechnology research, microbiology, molecular biology and neuroscience, and atomic, chemical, molecular and nuclear physics. Counts of five or fewer are not reported at the request of SRS, NSF.

We find that approximately 10 percent of degrees awarded to individuals from the 26 countries were in sensitive fields. By far the largest number of recipients of sensitive degrees came from Turkey and Iran, followed at a distance by Pakistan, Malaysia, Egypt and Jordan.

The popular press is full of stories of scientists trained abroad in sensitive fields who return to their home to work on nuclear weapons or chemical warfare. To get some idea of whether individuals from these 26 countries are likely to have returned home, we examine their reported "stay plans" upon completion of their Ph.D. While the response to this question can invite deception or optimism, it is the best indicator that we have from the data. Column 5 reports these stay rates, first across all S&E fields and then, in parentheses, for sensitive fields. Forty-three percent of the 7,110 report that they plan to stay; for those in sensitive fields reported stay plans are higher by about 12 points. Those from Iraq report above average stay plans, across the board and in sensitive areas.

Plans to stay in the U.S. are particularly high (over 60%) for those receiving Ph.D.s from Bangladesh, Lebanon and Iran. Moreover, in all three cases, the plans to stay for those receiving training in highly sensitive fields are generally higher. Plans to stay are below 10 percent for students from a number of Persian Gulf countries, including Jordan, Oman, Qatar, Saudi Arabia and Yemen. Students from North African countries

have below-average plans to stay in the U.S., although, with the exception of Eritrea, the stay plans are not as low as are those for students from the Persian Gulf.

Selectivity of Institutions. Figure 3 shows the distribution of temporary residents earning S&E Ph.D.s in the U.S. during the period 1981-99 by top-ten and non-top-ten ranked Ph.D. programs. Rankings, in almost all instances, are taken from the most recent National Research Council study.[4] After a gradual increase through the early 1990s, followed by a slight dip, the number of temporary residents from top programs remained fairly constant at around 1,000 during the remainder of the period. Because of the growth in foreign students during this period, the proportion of temporary residents from top ranked institutions fell considerably. In 1981, not quite one quarter (23.4%) of temporary resident Ph.D. recipients graduated from top programs; by 1999 this had dropped to 16.1 percent. It is not clear why this decrease occurred. Possible explanations include a change in the mix of program interest on the part of temporary residents; a change in quality of the applicant pool or the adoption of an implicit quota regarding the number of temporary residents in elite programs during the 1990s.

While only a minority of temporary residents in S&E graduate from a top institution, the proportion varies considerably by field. Table 2 shows the percent of doctorate recipients during the period 1981-99 who received their degrees from highly selective programs by field and citizenship status. While over 50 percent of temporary residents in oceanography (51.6%) and aerospace engineering (50.9%) graduated from

[4] A top institution in a given field is defined as one ranked in the top ten based on the National Research Council's 1993 ranking of scholarly quality for all fields except agriculture and medicine. A top institution in these two fields is defined as being among the top ten institutions for federally funded R&D expenditures in the given field. For our fields that are more broadly defined than the NRC program definitions, such as biology, our rankings are based on the mean of all NRC rated programs at an institution that fall under our field definition.

top ten programs in their fields, only 10.3 percent of those in chemistry and 6.8 percent of those in biology earned degrees from top-ten programs.

It does not follow that temporary residents are disproportionately absent from highly selective institutions. Indeed, there is little difference between temporary residents and U.S. citizens in the overall proportion of graduates from top institutions. Eighteen percent of temporary residents graduated from highly selective institutions compared to twenty percent of U.S. citizens. However, differences emerge across fields between temporary residents and citizens. In certain fields (chemistry, biological sciences, and physics), citizens are almost twice as likely to receive their degree from a top program than are temporary residents. In other fields (aerospace and astronomy) temporary residents are more likely to attend a top-rated program.

Section III: Stay Patterns

The U.S. scientific doctoral workforce has become increasingly foreign-born (Stephan and Levin 1999, 2001, 2003). While some doctoral scientists immigrate to the U.S. after receiving their Ph.D. abroad, many come for doctoral study and stay. Moreover, this pattern has increased during the past 20 years (Finn 2000). Increased stay rates, coupled with increased degrees awarded to individuals on temporary visas, have brought about an extraordinary increase in the number of foreign nationals who receive their degree and then work in the U.S. For example, the percentage increase in doctorates awarded to temporary residents who were in the U.S. three to four years after their degree, was 231 percent in the life sciences, 131 percent in the physical sciences and 93 percent in engineering between 1987-1988 and 1992-1993 (Finn 2000, p. 4). During the

comparable period, U.S. citizen doctorate recipients increased by only .9 percent in the physical sciences, 11.0 percent in the life sciences and 29.9 percent in engineering.

Figure 4 shows the percent of doctoral recipients on temporary visas who report that they plan to stay in the United States at the time they receive their Ph.D. We see that the increase was particularly noticeable during the period 1991-99.

Stay patterns vary considerably by country of origin, as seen in Figure 5. For example, if we take the top-ten sending countries, we find significant differences in stay patterns. Among the big four, those from China and India report the highest plans to stay; those from Taiwan and South Korea are significantly lower. Among the other ten countries, stay patterns are lowest for those from Brazil and Mexico.

These definitions of stay patterns are based on the respondent's answer to a question regarding location plans subsequent to graduation. Specifically, the question on the SED asks doctoral recipients to "name the organization and geographic location where you will work or study" for those indicating definite plans or to identify "in what state or country you intend to live after graduation" for all others. Although the question undoubtedly invites an optimistic response, Finn's (2000) research indicates that 53 percent of all students on temporary visas are in the United States three to four years after receipt of their degree. While Finn does not test to see how this relates to "stay plans," the stay-plans reported in Figure 4 are reasonably consistent with Finn's findings, especially when social scientists, who have the lowest stay rates, are eliminated from Finn's findings. Indeed, once this group is eliminated, the stay patterns that Finn reports vary between a low of 50 and a high of 62, depending on field and cohort.

In an effort to understand underlying factors affecting stay plans, we estimate a logit model for the 74,400 scientists and engineers in the 16 fields who indicate their stay plans in the survey for the period 1981-1999. Missing from the analysis are 20,074 of the 94,474 temporary residents who received a doctorate in S&E during this period: 14,209 individuals who do not reply to the postdoctoral location question, 469 individuals with an S&E degree not in one of the 16 fields, and 5,396 individuals for whom there are missing observations on the independent variables of interest.[5]

Variables are defined in Table 3 and means and standard deviations are presented. The logit results are presented in Table 4. The omitted field is biology, and the omitted countries are non-top-ten.[6] In addition to showing the logit coefficients and levels of significance, we report the marginal effect, evaluated at the means, of a change in the independent variable. In the case of a dummy variable, these marginal effects show by how much the probability will change with a change in status; in the case of a continuous variable, they show how much the probability will change with a one unit change in the value of the variable.

We find that demographics play a decisive role in determining stay patterns: age and marital status matter. Consistent with human capital theory, stay patterns decrease (and at a decreasing rate) with age. Married individuals are less likely to stay, possibly reflecting the challenge of finding two positions in the U.S. as well as the spouse's pull to return to the native country.

Ties to the U.S. also dramatically affect stay plans. Particularly noticeable is the strong positive impact of having received one's BA from the U.S., which increases the

[5] Those who don't reply to the stay question tend to be slightly older, less likely to be married, and were more likely to have received their Ph.D.s in the earlier period of observation.
[6] Also omitted are "other" predoctoral status.

probability of staying by .11. Work experience in the U.S. also plays an important role. Those who were working full time the year prior to receiving their Ph.D. are significantly more likely to plan to stay, as are those who were working part time. Those who report that they were not working are significantly less likely to plan to stay. Being supported by a fellowship also significantly increases the likelihood that one plans to stay.[7] A plausible explanation is that individuals on fellowships build stronger networks with U.S. researchers than those who are not on fellowships. There is also the related factor that individuals on fellowships are selected for their ability and recipients realize that this signals U.S. employers concerning their quality.

Stay plans, as indicated earlier, also depend on nationality. The probability of a Chinese student staying is .54 higher than is the probability of a student coming from a non-top ten source country. The probability of those from India staying is .38 higher; for those from Taiwan it is .07 higher. Stay patterns for those from South Korea are not significantly different from the benchmark. Stay patterns from the two major sending countries south of the boarder (Brazil and Mexico) are considerably lower.

Stay plans are directly related to field of training. This is not surprising, especially since the ability to stay in the U.S. if one holds a temporary visa at the time of receipt of the degree depends in part upon one's ability to receive a work permit or training permit. In certain fields work permits are more easily obtained than in others. This was especially the case during the IT boom of the mid to late 1990s. Also, work visas are not required for individuals planning to take a postdoctoral position, since such

[7] The omitted category is unknown experience during the previous year.

positions qualify as training.[8] Broadly speaking, these postdoctoral positions are most likely to be for those trained in the field of biology, the benchmark field in the estimated equation. The raw data reflect this fact. The highest overall stay plans of any discipline occur in biology, where 73 percent indicate that they plan to reside in the U.S. after finishing their degree.

Computer science and electrical engineering were two fields in high demand during the 1990s in which H1B visas were often issued. It is therefore not surprising to find that stay plans in these two fields are only slightly lower than in the post-doc oriented biological sciences, where stay patterns are particularly high. We find those trained in chemistry to be even more likely to plan to stay than those in the biological sciences. This undoubtedly reflects the dual opportunities available to chemistry Ph.D.s of either going to industry or of taking a posdoc position.

On the other hand, those receiving Ph.D.s in the earth sciences and oceanography are considerably less likely to stay, relative to the benchmark, as are those trained in agriculture and medicine. The earth science and oceanography result may well reflect the fact that the U.S. does not enjoy the dominant position in these fields worldwide. Indeed, these are two fields that some U.S.-born scientists consistently choose to receive their doctoral training in outside the U.S. The strong agricultural result may be consistent with the fact that source countries invest in the training of scientists in agriculture with the expectation that they will return home. Finn (2000) also finds low actual stay rates among those trained in agriculture.

[8] Students study in the U.S. on an F visa. Generally speaking, a student can stay up to one year after graduation on an F visa to obtain optional practical training. Many post doc recipients hold J visa status. The H visa is a temporary work visa and is specific for job and site. It is issued for up to three years and can be renewed for up to an additional three years.

The field results are affected, in many instances, by the quality of the Ph.D. program where the training was received. Drawing on the 1993 National Research Council's ranking of graduate programs, we classify the Ph.D. program into a top vs. non-top program by field.[9] We find that those trained in top electrical engineering programs as well as top computer science programs are more likely to stay than those trained in non-top programs in these fields. This is consistent with U.S. demand being higher for individuals from strong programs as well as the willingness of potential employers to seek visas for exceptionally well-trained temporary residents. We also see that those trained at top mechanical engineering programs are more likely to plan to stay. Interestingly enough, we find that those from top oceanography programs are more likely to stay, compared to those trained at lower-rated programs.

Overall, the quality results are consistent with the findings of Stephan and Levin (2003), which suggest that the foreign-born who work in the U.S. represent a highly select group. While Stephan and Levin focus on the selectivity process that draws high achieving students to the U.S., these results suggest that it is not only selection in terms of who comes but also selection in terms of who stays.[10]

The SED not only ascertains the plans of individuals; it also ascertains whether individuals have "definite plans," meaning that the individual has plans to return to or continue in predoctoral employment, or is negotiating a contract or has a contract with a specific employer. For positions located in the U.S., the definite plan question provides a different lens for viewing the locational plans of Ph.D. recipients on temporary visas.

[9] See footnote 4 for the definition of a "top program."
[10] But, those from top programs do not always indicate a higher likelihood of staying. In particular, we find that those from top medical programs are less likely to stay than are those from non-top programs.

We find that 44 percent of temporary residents who received their Ph.D. during the period 1981-1999 have "definite plans to stay," compared to 64 percent with "plans to stay." Column five of Table 4 reports the marginal effects of independent variables when the dependent variable is switched from "plans to stay" to "definite plans to stay."

The results are fairly consistent with those reported earlier. Older individuals are less likely to stay. However, we cannot reject the hypothesis that marital status does not matter, and we find that the probability of staying is .024 higher for women than for men.

Experiences during doctoral training have powerful effects on the probability that a temporary resident stays in the U.S. For example, having fulltime employment during the last year of graduate school increases the probability of definitely staying by .24. Likewise, working part-time increases the probability by .16. The effect of having received one's BA degree in the U.S., however, is muted, compared to the case of planning to stay.

We also find that country of origin plays less of a role in determining definite plans. Other things being equal, for example, being Chinese increases the probability by .23; being Indian increases the probability by .26. Far from inconsequential, these effects are substantially lower than the country effects in determining stay plans. On the other hand, when the lens is switched to this tighter measure of work plans, we find that citizens from Mexico and Brazil indicate at the same rate that they plan to leave the U.S.

When the dependent variable is measured in terms of "definites," the field effects are considerably enhanced. Relative to the benchmark of biology (with its high postdoc rate), all other fields are less likely to stay, and in many instances the effect is considerable. The field that is least likely relative to the benchmark is once again

agriculture. Civil engineering and oceanography are not far behind. Even those trained in the strong demand sectors of electrical engineering and computer science report considerably lower plans to stay than those in biology. This effect washes out when we focus on those trained at top programs. Indeed, combining results, we conclude that temporary residents who earn degrees in computer science from top-rated programs are more likely to stay in the U.S. than are biologists.

A striking finding is that individuals trained at top programs are more likely to have definite plans to stay in the U.S. than are individuals who are not trained at top programs. There is but one exception: Those trained at top medical programs are less likely to stay than are those trained at lower rated medical programs.

We conclude that stay plans as well as definite plans are clearly related to age, field, country of origin and quality of training. The field with the highest stay rate is biology/chemistry. The field with the lowest stay rate is agriculture. Individuals trained at top programs consistently are more likely to have definite plans to stay than are individuals trained at lower tier institutions.

Work and fellowship experiences in graduate school also clearly relate to staying. It is, of course, difficult to know whether these experiences are causal or reflect underlying characteristics that place these individuals in high demand in the U.S. Suffice it to say, however, that these experiences are an extraordinarily good predictor of whether the individual will stay in the U.S.

Taken together, these effects can be quite strong. For example, the probability that a 33-year old unmarried male Chinese student, supported on a fellowship, who received a Ph.D. in 1997 from a top-rated program in biology and did not earn a

bachelor's degree in the U.S., plans to stay is .98; it is .76 that he has definite plans to stay. The probability for a comparable individual from India with a Ph.D. from a top institution in computer science is similar: .94 for plans to stay and .79 for definite plans to stay. For others the probability is much lower. For instance, the probability that a Mexican student who received a Ph.D. in agriculture from a non-top program plans to stay in the U.S. is .28; it is .15 that he has definite plans to stay in the U.S.

Industrial employment. For the years 1997-1999 we not only know if individuals plan to stay in the U.S. but, as part of a larger study, for those who have definite plans to work in industry we know the identity and location of the firm where they have such plans (Stephan et al 2003).

We find that 32 percent of those with definite plans to work in industry are temporary residents at the time of graduation. This is approximately the same proportion as the underlying representation of temporary residents in the population of new Ph.D.s during the time period. Definite plans to work in industry by field of training are provided in Table 5. The rate is particularly high in civil and electrical engineering. The rate is also relatively high in math (43%) and computer science (38%). In all instances, these rates closely resemble the underlying proportion of temporary residents in the population of newly minted Ph.D.s during the same period.

When we look at country of origin, we find that the largest number of foreign industrial hires among these new Ph.D.s come from China. Indeed, the Chinese representation among the industrial hires is so strong that almost one in three of the temporary residents hired by industry is Chinese and close to one in ten of all industrial

hires identified in these data is Chinese. Indian hires are a close second, with more than one in twelve of industrial hires during the period being Indian.

A substantial portion of temporary residents are employed in large established firms. Forty percent had definite plans for employment at a firm ranked in the top 200 for R&D expenditures or at one of these firms' subsidiaries. India placed the largest number of hires in top 200 R&D firms, followed by China and Taiwan. These three countries accounted for 70 percent of temporary resident hires at top 200 R&D firms; in comparison, they made up approximately two-thirds of temporary resident hires at non-top R&D firms.

Section IV: Summary and Conclusion

Temporary residents play a key role in S&E Ph.D. programs in the United States. During the period under study, approximately one in three degrees in S&E was awarded to a student on a temporary visa. In certain fields, such as electrical engineering, math and computer science, the percent is significantly higher.

The lion's share of Ph.D. students on temporary visas during the past two decades came from four countries: The People's Republic of China, India, Taiwan and South Korea. These patterns, however, are in the process of changing as Taiwanese and Korean students increasingly choose to remain in their country to receive their Ph.D. training.

Stay patterns have been increasing over time and are a major contributor to the internationalization of U.S. science. Stay patterns vary considerably by country of origin and field of training. Of the largest sending countries, the Chinese are most likely to stay,

Brazilians least likely to stay. Biologists have the highest probability of staying; those trained in agriculture have the lowest probability of staying. These trends undoubtedly are influenced by the large number of postdoctoral positions available in the biological sciences. We also find strong evidence that those trained at top programs are more likely to plan to stay than are those trained at non-top programs.

The descriptive nature of this paper leaves many questions unanswered. The model to predict the probability of staying in the U.S., for example, falls short of telling a complete story. To correct its shortcomings, further work is needed to include other key elements expected to influence the location decision, including demand in the U.S. and the state of demand in the sending country. We would expect, for example, that a student from a country with a strong scientific infrastructure to be less likely to plan to stay in the U.S. given the likelihood of adequate opportunities for a scientific career in their home country. Moreover, changes in demand for Ph.D.s in the U.S. as well as in the home country are expected to play a significant role in a student's plans to stay in the U.S. With the end of the recent IT boom and a continuing sluggish economy in the U.S., foreign students, particularly in certain fields, may perceive far lower chances of obtaining employment in the U.S. and make plans to leave the U.S. after graduate study. Methodological questions also arise concerning the treatment of selectivity in the stay model. As we indicated earlier, slightly more than 15 percent of the temporary residents were dropped from the analysis due to lack of information on the dependent variable. We have yet to investigate how this censoring on the dependent variable affects the results.

In addition, this preliminary analysis raises many questions that invite further research. For instance, why has the level of temporary residents trained in top programs

remained constant for most of the 1990s as the overall number of temporary residents earning Ph.D.s has steadily increased? Are there institutional factors, such as quotas on foreign students, which have driven this outcome? More broadly, has the changing composition of foreign students affected their education and employment patterns? Are underlying factors jointly influencing these students' decisions about studying in the U.S., choosing a field, and staying in the U.S. after graduation? Is the high stay rate for foreign students in biology a factor in encouraging foreign students to choose to study biology in the U.S.? These—and many other questions—invite further investigation.

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Figure 1

Citizenship Status of S&E Doctorates by Year of Degree

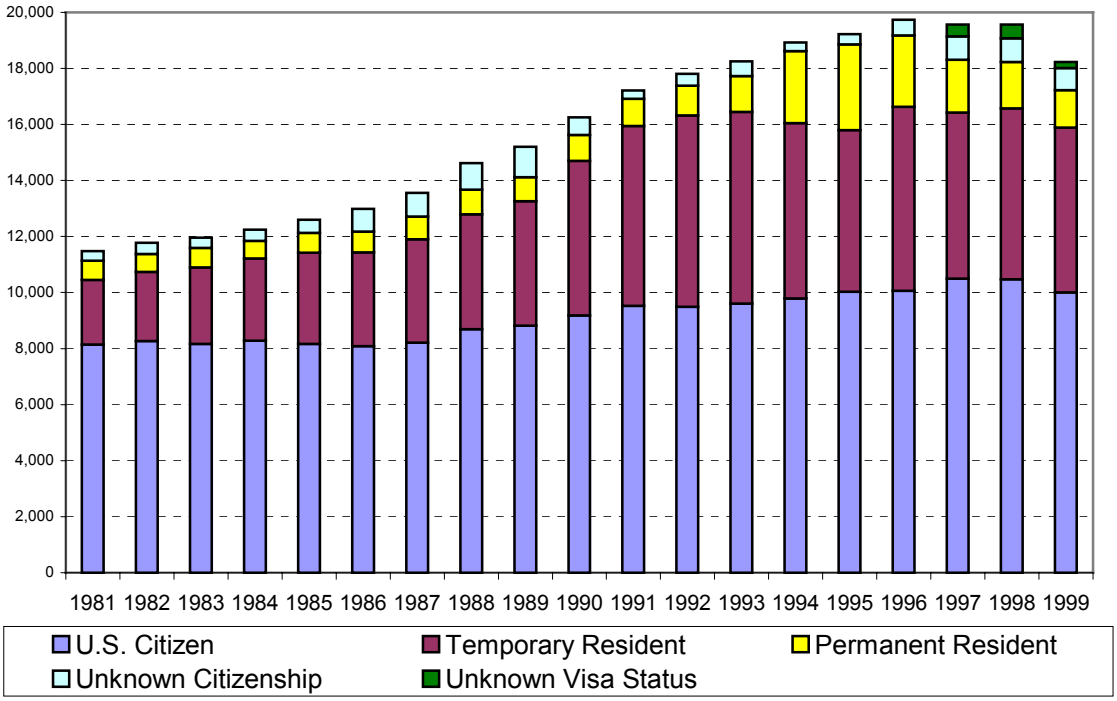

Figure 2

Proportion of Temporary Residents Receiving S&E Doctorates in the United States in the 1990s by Country of Citizenship

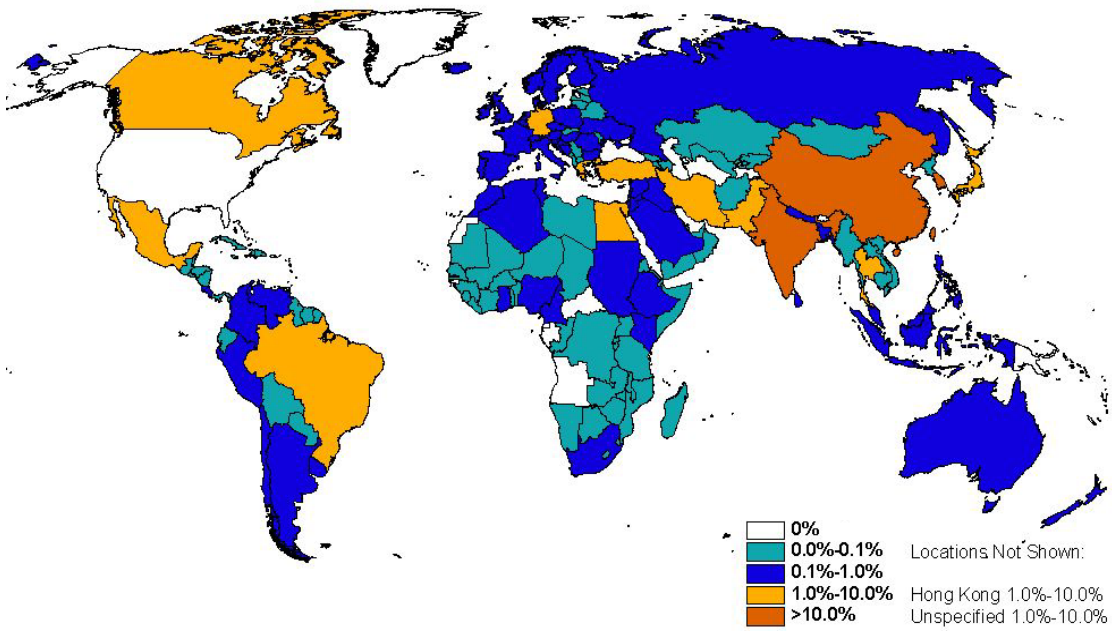

Figure 3

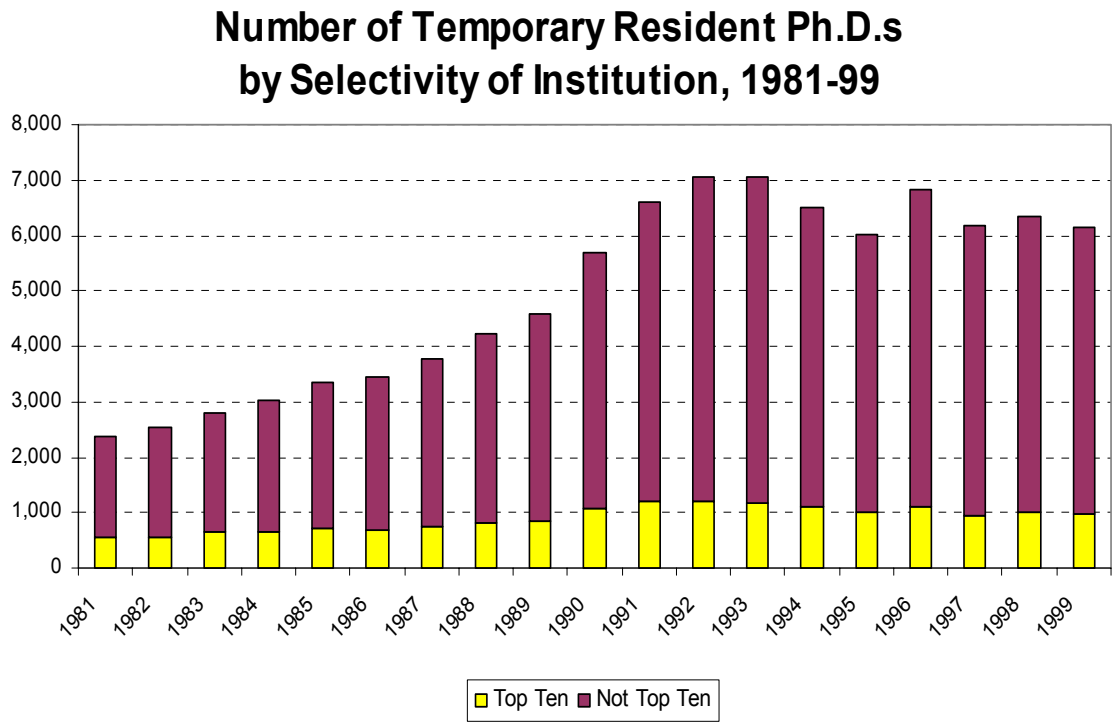
Number of Temporary Resident Ph.D.s
by Selectivity of Institution, 1981-99
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
Top Ten
Not Top Ten

Figure 4

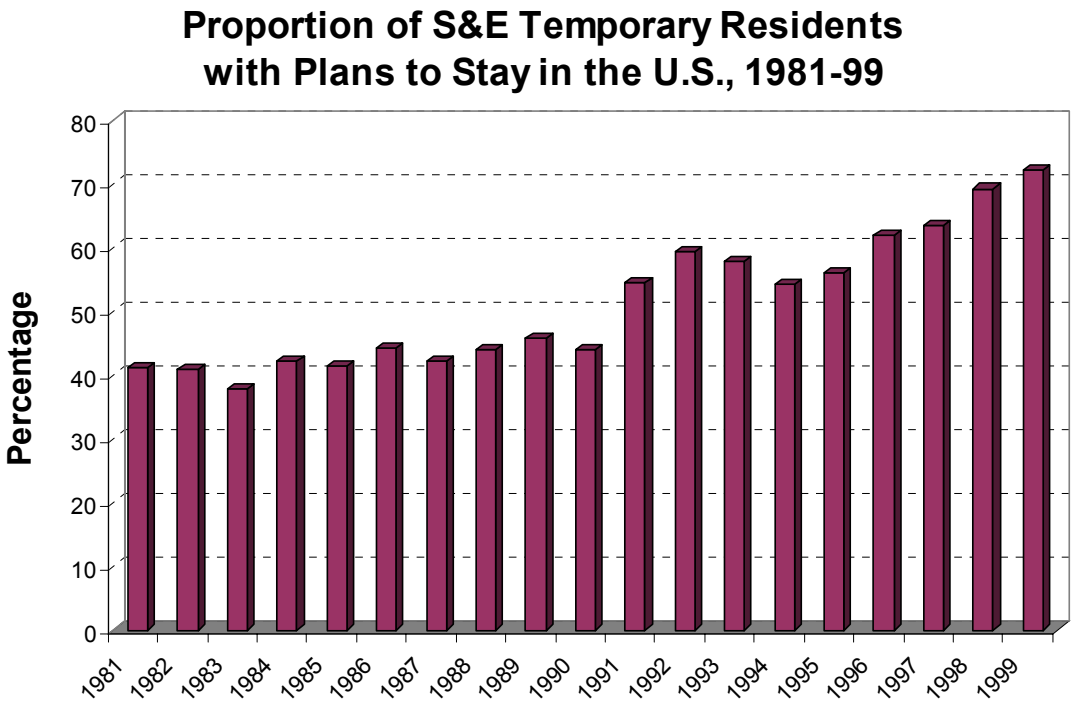
Proportion of S&E Temporary Residents with Plans to Stay in the U.S., 1981-99
Percentage
80
70
60
50
40
30
20
10
0
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999

Figure 5

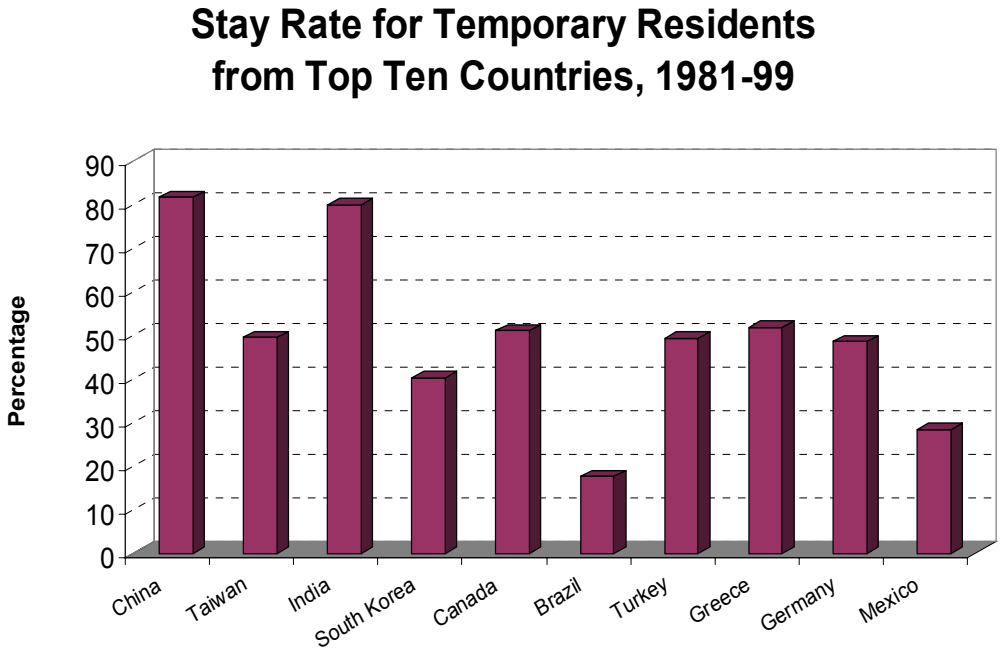
Stay Rate for Temporary Residents from Top Ten Countries, 1981-99
Percentage
90
80
70
60
50
40
30
20
10
0
China
Taiwan
India
South Korea
Canada
Brazil
Turkey
Greece
Germany
Mexico

Table 1
Ph.D.s Awarded in Science and Engineering, 1990-99, to Temporary Residents from Countries on U.S. State Department Watch List

Country	S&E Ph.D.s	Percentage of all Ph.D.s	Sensitive Fields	Stay Rate for All (Sensitive Fields)
Afghanistan	s	S	s	50.0 (s)
Algeria	186	0.09	18	25.8 (66.7)
Bahrain	19	0.01	s	21.1 (s)
Bangladesh	323	0.16	32	73.1 (72.0)
Egypt	801	0.41	53	35.2 (43.4)
Eritrea	8	0.00	s	75.0 (s)
Indonesia	453	0.23	44	23.4 (59.1)
Iran	898	0.45	117	62.7 (78.6)
Iraq	119	0.06	14	48.7 (71.4)
Jordan	495	0.25	53	46.5 (60.4)
Kuwait	84	0.04	9	6.0 (s)
Lebanon	355	0.18	36	69.0 (80.6)
Libya	41	0.02	s	34.1 (s)
Malaysia	417	0.21	65	44.4 (55.4)
Morocco	156	0.08	15	21.8 (s)
Oman	14	0.01	s	7.1 (s)
Pakistan	753	0.38	73	36.7 (57.5)
Qatar	19	0.01	s	5.3 (s)
Saudi Arabia	413	0.21	27	4.6 (s)
Somalia	16	0.01	s	62.5 (s)
Sudan	95	0.05	7	35.8 (s)
Syria	102	0.10	9	57.8

				(77.8)
Tunisia	195	0.54	14	32.8 (s)
Turkey	1060	0.02	117	50.4 (44.4)
United Arab Emirates	48	0.02	13	37.5 (53.8)
Yemen	40	0.02	s	10.0 (s)
Total	7110*	3.60	732	42.7 (56.1)

s=suppressed if count is less than six
*Excluding suppressed count

Table 2
Doctoral Education at Highly Selective Programs, 1981-99

Field	Percent of All Doctorate Recipients	Percent of Temporary Residents	Percent of U.S. Citizens
Aerospace Engineering	47.6	50.9	44.4
Agriculture	29.6	29.2	30.1
Astronomy	37.8	40.4	37.1
Biological Sciences	10.7	6.8	11.4
Chemical Engineering	27.7	19.3	36.6
Chemistry	17.4	10.3	20.1
Civil Engineering	27.4	27.2	27.9
Computer Sciences	22.6	19.3	24.8
Earth Sciences	20.8	18.3	20.7
Electrical Engineering	28.7	23.1	32.3
Mathematics	20.7	19.6	20.1
Mechanical Engineering	27.5	23.7	32.2
Medicine	16.4	14.3	17.3
Oceanography	53.7	51.6	52.7
Other Engineering	17.3	13.4	19.2
Physics	22.9	15.9	27.0
ALL S&E	19.9	18.1	20.5

Table 3
Descriptive Statistics

Variable	Definition	Mean (Std. Dev.)
STAY	Dummy variable indicating whether or not an individual has intentions to stay in the U.S. regardless of the definiteness of those plans	0.64 (0.48)
DEFSTAY	Dummy variable indicating whether or not an individual has definite plans to stay in the U.S., based on plans to return to or continue in predoctoral employment, or negotiations or a contract with a specific employer	0.44 (0.50)
AGE	Age of the individual at time of Ph.D.	33.0 (4.4)
AGE SQUARED	Age of the individual squared	1109.5 (312.4)
FEMALE	Dummy variable indicating whether or not an individual is female	0.16 (0.36)
MARRIED	Dummy variable indicating whether or not an individual was married at time of Ph.D.	0.62 (0.49)
PREFTEMP	Dummy variable indicating whether or not an individual was full-time employed one year prior to Ph.D.	0.27 (0.44)
PREFELLOW	Dummy variable indicating whether or not an individual was supported by fellowships or assistantships one year prior to Ph.D.	0.54 (0.50)
PREPTEMP	Dummy variable indicating whether or not an individual was part-time employed one year prior to Ph.D.	0.07 (0.25)
PRENOTEMP	Dummy variable indicating whether or not an individual was not employed one year prior to Ph.D.	0.09 (0.29)
PREOTHER	Dummy variable indicating whether or not an individual held any other predoctoral status one year prior to Ph.D. (including unknown status)	0.03 (0.18)
US BACHELORS	Dummy variable indicating whether or not an individual received a bachelor's degree from an institution in the United States	0.07 (0.25)
CHINA	Dummy variable indicating whether or not an individual was a citizen of China at time of Ph.D.	0.16 (0.37)
TAIWAN	Dummy variable indicating whether or not an individual was a citizen of Taiwan at time of Ph.D.	0.14 (0.35)
INDIA	Dummy variable indicating whether or not an individual was a citizen of India at time of Ph.D.	0.12 (0.33)
SOUTH KOREA	Dummy variable indicating whether or not an individual was a citizen of South Korea at time of Ph.D.	0.10 (0.30)
CANADA	Dummy variable indicating whether or not an individual was a citizen of Canada at time of Ph.D.	0.03 (0.17)
BRAZIL	Dummy variable indicating whether or not an	0.02

	individual was a citizen of Brazil at time of Ph.D.	(0.15)
TURKEY	Dummy variable indicating whether or not an individual was a citizen of Turkey at time of Ph.D.	0.02 (0.13)
GREECE	Dummy variable indicating whether or not an individual was a citizen of Greece at time of Ph.D.	0.02 (0.13)
GERMANY	Dummy variable indicating whether or not an individual was a citizen of Germany at time of Ph.D.	0.01 (0.12)
MEXICO	Dummy variable indicating whether or not an individual was a citizen of Mexico at time of Ph.D.	0.02 (0.13)
AERE	Dummy variable indicating whether or not an individual's Ph.D. field was aerospace engineering	0.01 (0.12)
CHEE	Dummy variable indicating whether or not an individual's Ph.D. field was chemical engineering	0.05 (0.21)
CIVE	Dummy variable indicating whether or not an individual's Ph.D. field was civil engineering	0.05 (0.22)
ELEE	Dummy variable indicating whether or not an individual's Ph.D. field was electrical engineering	0.10 (0.30)
MECE	Dummy variable indicating whether or not an individual's Ph.D. field was mechanical engineering	0.06 (0.24)
OENG	Dummy variable indicating whether or not an individual's Ph.D. field was another engineering field	0.12 (0.32)
ASTR	Dummy variable indicating whether or not an individual's Ph.D. field was astronomy	0.01 (0.07)
CHEM	Dummy variable indicating whether or not an individual's Ph.D. field was chemistry	0.10 (0.30)
PHYS	Dummy variable indicating whether or not an individual's Ph.D. field was physics	0.08 (0.27)
EART	Dummy variable indicating whether or not an individual's Ph.D. field was earth sciences	0.02 (0.15)
OCEA	Dummy variable indicating whether or not an individual's Ph.D. field was oceanography	0.004 (0.07)
MATH	Dummy variable indicating whether or not an individual's Ph.D. field was mathematics	0.07 (0.26)
COMP	Dummy variable indicating whether or not an individual's Ph.D. field was computer sciences	0.05 (0.21)
AGRI	Dummy variable indicating whether or not an individual's Ph.D. field was agricultural sciences	0.09 (0.28)
BIOL	Dummy variable indicating whether or not an individual's Ph.D. field was biological sciences	0.15 (0.36)
MEDI	Dummy variable indicating whether or not an individual's Ph.D. field was medicine	0.04 (0.19)
TOPAERE	Dummy variable indicating whether or not an individual's Ph.D. institution was ranked in the top ten for aerospace engineering	0.007 (0.08)
TOPCHEE	Dummy variable indicating whether or not an individual's Ph.D. institution was ranked in the top ten for chemical engineering	0.01 (0.01)
TOPCIVE	Dummy variable indicating whether or not an individual's Ph.D. institution was ranked in the top ten for civil engineering	0.01 (0.12)

TOPELEE	Dummy variable indicating whether or not an individual's Ph.D. institution was ranked in the top ten for electrical engineering	0.02 (0.15)
TOPMECE	Dummy variable indicating whether or not an individual's Ph.D. institution was ranked in the top ten for mechanical engineering	0.01 (0.12)
TOPOENG	Dummy variable indicating whether or not an individual's Ph.D. institution was ranked in the top ten for other engineering fields combined	0.01 (0.12)
TOPASTR	Dummy variable indicating whether or not an individual's Ph.D. institution was ranked in the top ten for astronomy	0.002 (0.05)
TOPCHEM	Dummy variable indicating whether or not an individual's Ph.D. institution was ranked in the top ten for chemistry	0.01 (0.10)
TOPPHYS	Dummy variable indicating whether or not an individual's Ph.D. institution was ranked in the top ten for physics	0.01 (0.12)
TOPEART	Dummy variable indicating whether or not an individual's Ph.D. institution was ranked in the top ten for earth sciences	0.004 (0.07)
TOPOCEA	Dummy variable indicating whether or not an individual's Ph.D. institution was ranked in the top ten for oceanography	0.002 (0.05)
TOPMATH	Dummy variable indicating whether or not an individual's Ph.D. institution was ranked in the top ten for mathematics	0.02 (0.12)
TOPCOMP	Dummy variable indicating whether or not an individual's Ph.D. institution was ranked in the top ten for computer sciences	0.009 (0.10)
TOPAGRI	Dummy variable indicating whether or not an individual's Ph.D. institution was ranked in the top ten for agricultural sciences	0.02 (0.16)
TOPBIOL	Dummy variable indicating whether or not an individual's Ph.D. institution was ranked in the top ten for biological sciences	0.01 (0.10)
TOPMEDI	Dummy variable indicating whether or not an individual's Ph.D. institution was ranked in the top ten for medicine	0.005 (0.07)
PHD YEAR	Year the individual received his Ph.D.	1992 (4.87)

Table 4
Logit Estimation of the Stay Rate
(n=74,400)

	STAY		DEFSTAY	
	Estimated Coefficient.	Marginal Effect	Estimated Coefficient.	Marginal Effect
Intercept	-25.57	-5.33	38.17	9.37
Age	-0.11***	-0.029	-0.15***	-0.037
Age Squared	0.00091***	0.00019	0.0010***	0.00025
Female	0.041	0.0086	-0.097***	-0.024
Married	-0.099***	-0.021	0.0086	0.0021
Preftemp	0.19***	0.039	0.98***	0.24
Prefellow	0.52***	0.11	1.00***	0.25
Preptemp	0.46***	0.10	0.64***	0.16
Prenotemp	-0.25***	-0.051	-0.22***	-0.055
US Bachelors	0.52***	0.11	0.32***	0.079
China	2.61***	0.54	0.94***	0.23
Taiwan	0.34***	0.071	0.19***	0.046
India	1.84***	0.38	1.04***	0.26
South Korea	-0.041	-0.0086	-0.0012	-0.00029
Canada	-0.089	-0.018	0.17***	0.042
Brazil	-1.22***	-0.25	-1.07***	-0.26
Turkey	0.026	0.0054	0.086	0.021
Greece	0.025	0.0052	0.097	0.024
Germany	-0.28***	-0.058	-0.0044	-0.0011
Mexico	-0.62***	-0.13	-0.49***	-0.12
Aere	-0.61***	-0.13	-1.05***	-0.26
Chee	-0.46***	-0.096	-0.66***	-0.16
Cive	-0.69***	-0.14	-0.97***	-0.24
Elee	-0.26***	-0.053	-0.51***	-0.12
Mece	-0.51***	-0.11	-0.82***	-0.20
Oeng	-0.51***	-0.11	-0.71***	-0.18
Astr	-0.26*	-0.055	-0.33**	-0.081
Chem	0.13***	0.027	-0.11***	-0.027
Phys	-0.21***	-0.043	-0.35***	-0.085
Eart	-0.62***	-0.13	-0.59***	-0.15
Ocea	-0.94***	-0.20	-0.93***	-0.23
Math	-0.53***	-0.11	-0.54***	-0.13
Comp	-0.39***	-0.081	-0.43***	-0.11
Agri	-1.20***	-0.25	-1.24***	-0.30
Medi	-0.62***	-0.13	-0.54***	-0.13
Topaere	0.22	0.045	0.38***	0.094
Topchee	0.12	0.025	0.48***	0.12
Topcive	-0.067	-0.014	0.16*	0.038
Topelee	0.31***	0.064	0.43***	0.10
Topmece	0.27***	0.057	0.32***	0.078
Topoeng	-0.031	-0.0065	0.029	0.0071
Topastr	-0.32	-0.066	0.062	0.015

Topchem	0.084	0.017	0.44***	0.11
Topphys	-0.035	-0.0072	0.29***	0.071
Topeart	0.10	0.022	0.096	0.024
Topocea	0.64***	0.13	0.74***	0.18
Topmath	0.062	0.013	0.34***	0.084
Topcomp	0.39***	0.082	0.69***	0.17
Topagri	-0.089	-0.019	-0.061	-0.015
Topbiol	0.23**	0.049	0.23***	0.057
Topmedi	-0.40***	-0.082	-0.45***	-0.11
Phd Year	0.015***	0.0031	-0.018***	-0.0044

*Significant at the 10% level
**Significant at the 5% level
***Significant at the 1% level

Table 5
Field of Training of S&E Temporary Residents
with Definite Plans for Industry Employment
in the U.S., 1997-99

Field	Number of Temporary Resident	Number of all Doctorate Recipients	% of Temp Residents
Aerospace Engineering	36	159	22.6%
Chemical Engineering	254	754	33.7%
Civil Engineering	122	292	41.8%
Electrical Engineering	763	1,860	41.0%
Mechanical Engineering	293	738	39.7%
Other Engineering	436	1,238	35.2%
Agriculture	57	272	21.0%
Astronomy	9	44	20.5%
Biological Sciences	86	574	15.0%
Chemistry	207	1,175	17.6%
Computer Sciences	282	737	38.3%
Earth Sciences	59	219	26.9%
Mathematics	197	457	43.1%
Medicine	73	415	17.69%
Oceanography	2	6	33.3%
Physics	181	626	28.9%
ALL S&E	3,057	9,566	30.8%