Stay Rates of Foreign Doctorate Recipients from U.S. Universities, 1999

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Highlights

This study used income and Social Security tax records to estimate the proportion of foreign doctorate recipients from U.S. universities who stayed in the United States after graduation. Findings:

- Half (51 percent) of temporary residents who received S/E doctorates from U.S. universities in 1994 and 1995 were in the United States in 1999.

- Nearly two-thirds (63 percent) of temporary residents who received S/E doctorates from U.S. Universities in 1997 were in the United States in 1999.

- The 63 percent stay rate for the Class of 1997 in 1999 is a record high. An analysis of the reasons why this is so much higher than the 51 percent stay rate recorded for the Classes of 1994 and 1995 in 1999 indicates:

  Nearly half of the difference is due to a shift in the proportion of temporary resident students coming from different countries. A temporary law caused many of the doctorate recipients from China to become permanent residents prior to graduation. This depressed the overall stay rate for temporary residents from the 1994/95 classes because Chinese students have the highest stay rate.

  Slightly more than half of the difference is due to increased stay rates for temporary resident students from the various individual countries of origin.

- A stay rate for all foreign doctorate recipients observed two years after graduation (i.e., including those on permanent visas at graduation) was estimated as well. This rate increased from 49 percent in 1989 to 69 percent in 1999.

- Among discipline groups the highest stay rates were recorded for computer/EE engineering, computer science, and the physical sciences. The stay rate in the social sciences was the lowest.

- Most foreign doctorate recipients come from the four largest source countries. The stay rates vary dramatically for temporary residents from these four countries: China (91 percent) and India (87 percent) are very high, while Taiwan (42 percent) is relatively low, and Korea (15 percent) is very low.

- Stay rates were also estimated for the Class of 1989. About 50 percent were here in 1999. A larger proportion, about 63 percent, paid taxes on U.S. earnings during at least one year out of the 10 years following their graduation, indicating that for every four who were here in 1999 there was one more who had worked here but was no longer here in 1999.

Introduction

This report provides estimates of stay rates for foreign students who received doctorates in science or engineering (S/E) from U.S. universities. For this paper, the stay rate is taken to mean the proportion of foreign doctorate recipients from U.S. universities that stayed in the United States after graduation for any reason. The stay rate is always specific to a particular year, e.g., 1999. Each line in the several tables that follow describes a different group of these degree recipients.

Data and Methods

The stay rate estimates from this report are derived by assembling groups of Social Security numbers of doctoral recipients and obtaining a special tabulation of data from tax authorities. If a foreign doctorate recipient earned $5,000 or more and paid taxes on it, they were defined as a stayer. Adjustments were made for missing Social Security numbers, mortality, and for the relatively small proportion of recent doctorate recipients who stay in the United States but do not earn at least $5,000. The method used to make adjustments to data received from tax authorities has changed somewhat from earlier reports because the data received are now based on both Social Security taxes and income taxes paid. This increases confidence in the estimates. The improvement has not changed results enough to affect the comparability of these estimates with those produced in earlier years, however. See Technical Appendix for a detailed discussion.

Stay Rates of Temporary Residents

Table 1 provides stay rates for 1997 foreign doctorate recipients in 1998 and 1999. This table contains information only on persons with a temporary visa at the time of graduation.

Table 1. Temporary Residents Receiving S/E Doctorates from U.S. Universities in 1997 Who Were in the United States, by Degree Field, 1998 to 1999

Degree Field	Foreign Doctorate Recipients	Percent in the United States	
		1998	1999
Physical sciences	1,232	74	73
Mathematics	416	68	66
Computer science	315	74	73
Agricultural science	351	48	46
Life sciences	1,283	71	69
Computer/EE engineering	649	82	81
Other engineering	1,746	63	60
Economics	449	35	34
Other social sciences	500	39	37
Total, All S/E fields	**6,941**	**65**	**63**

Note: Other social science includes psychology.
Source: Oak Ridge Associated Universities.

The overall stay rate for 1997 Ph.D. recipients in 1999 was 63 percent. Computer/EE engineering, physical science, and computer science have rates that are about twice as high as the rates in economics and social sciences. While it is difficult to say why these rates differ, it is certainly plausible that the boom in high-tech industries in 1999 was a factor. The high overall rate of 63 percent was not solely the result of these fields, however. Mathematics and life sciences also had rates that were above average.

The stay rates for 1997 doctorate recipients in 1999 are sharply higher than stay rates for similar but earlier cohorts. (Table 2.) Every field group in Table 2 shows a record high stay rate in 1999, but perhaps most noteworthy are the physical and life sciences where the stay rate increased by 20 and 21 percentage points respectively in the two-year period from 1997 to 1999. These increases are real, and in the case of the life sciences, indicate a very dramatic change from earlier years. However, comparisons from 1997 to 1999 in the stay rate for temporary residents are also affected by another phenomenon, which complicates interpretation of this dramatic change.

Table 2. Temporary Residents Receiving S/E Doctorates from U.S. Universities Who Were in the United States Two Years After Graduation, 1986 to 1999

	Percent in the United States					
	1986	1989	1992	1995	1997	1999
Total, S/E fields	**40**	**36**	**45**	**51**	**47**	**63**
Physical sciences	46	38	52	59	52	72
Life sciences	24	22	38	57	43	64
Social sciences	26	28	27	26	27	35
Engineering	52	44	52	51	57	66

Note: The estimates for 1989 and 1992 describe persons graduating one to two years prior to those years; for all others it is two years prior. In this table, the physical sciences category includes mathematics and computer science, life sciences includes agricultural science, and social science includes psychology.

Source: ORAU; data for 1986 and 1989 are from Finn, Pennington, and Anderson, 1995; data for 1992 and 1995 are from Finn, 1998; data from 1997 from Finn, 2000.

In the most common terminology "foreign students" includes only those on temporary visas. Other non-U.S. citizens who are students while on permanent visas are typically not viewed as foreign students. However, two things happened during the 1990s that indicate a broader definition of foreign students may be appropriate. First, China became the largest single source country for new foreign doctorates in science and engineering fields in 1990[1]. Second, the Chinese Student Adjustment Act granted permanent resident status to a large number of Chinese foreign students in the early 1990s. As these students finished their graduate programs this law resulted in a temporary reduction in students finishing Ph.D.'s while on temporary visas and an increase in the number finishing while on permanent visas. As can be seen from Table 3, the total number of doctorates awarded to permanent residents was unusually high for several years starting in 1994.

[1] NSF, Science and Engineering Doctorate Awards, 1998.

Table 3. S/E Doctorates Awarded by U.S. Universities, by Citizenship, 1989 to 1999

Citizenship	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, S/E	**21,732**	**22,868**	**24,023**	**24,675**	**25,443**	**26,205**	**26,535**	**27,229**	**27,245**	**27,309**	**25,953**
Total Non-U.S.	6,515	7,768	8,926	9,475	9,754	10,542	10,503	10,809	9,240	9,159	8,886
Temporary Visas	5,391	6,571	7,641	8,092	8,113	7,521	6,994	7,806	7,498	7,779	7,241
Permanent Visas	1,124	1,197	1,285	1,383	1,641	**3,021**	**3,509**	**3,009**	2,280	2,022	1,645
Total U.S.	13,468	14,167	14,629	14,559	14,932	15,166	15,487	15,630	16,122	16,246	15,783
Unknown	1,749	933	468	641	757	497	545	784	1,345	1,262	1,284

Source: NSF, Science and Engineering Doctorate Awards: 1999.

Figure 1 shows the dramatic drop in the proportion of temporary visas awarded to students from China after 1993. Since 1992, about one in four S/E doctorates awarded to foreign citizens were awarded to students from China. Thus, the drop in temporary visa graduates from China during 1994 to 1995 was offset by the increase in permanent visa graduates from China. Had it not been for the increased number of permanent visas given to students from China for a few years the temporary visa total would have been higher and the permanent visa total lower during the years after 1993. Since students from China stay more often than students from other countries, these shifts have depressed the 1997 stay rate for all students on temporary visas in Table 2.

Figure 1. Doctorates Awarded to Chinese Citizens as a Percentage of All S/E Doctorates Awarded by U.S. Universities to Non-U.S. Citizens, by Visa Type, 1990 to 1999
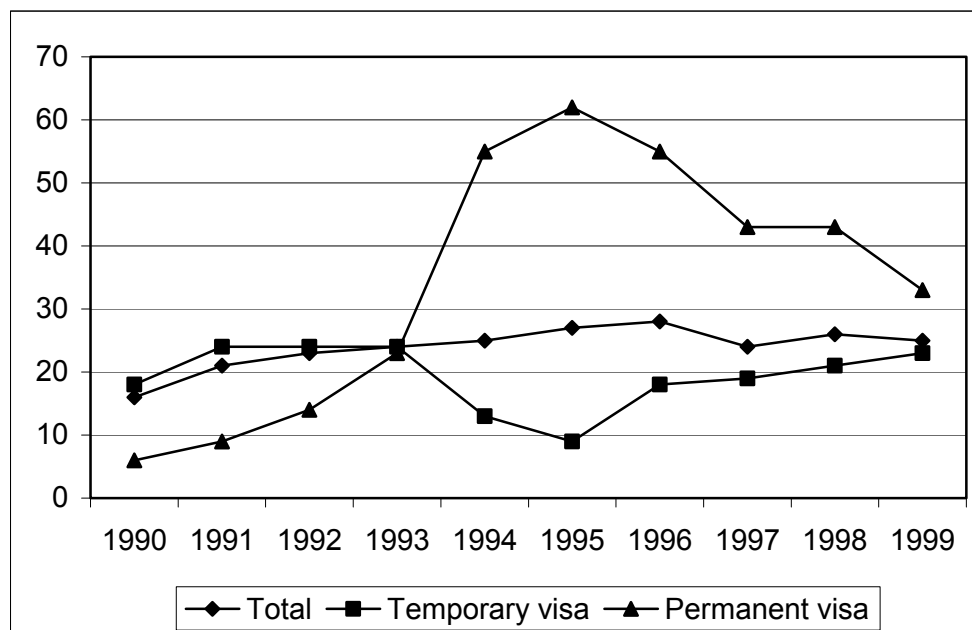
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, All Chinese	16	21	23	24	25	27	28	24	26	25
Temporary visa	18	24	24	24	13	9	18	19	21	23
Permanent visa	6	9	14	23	55	62	55	43	43	33

Source: Oak Ridge Associated Universities.

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Figure 2 shows stay rates for all foreign students, i.e., temporary and permanent residents. It does not show as many data points as Table 2 because estimates for permanent residents are not available for every year. If one considers only the stay rate for temporary residents, the increase after 1994 appears to be a continuation of an earlier trend. However, the stay rate for students who were on temporary or permanent visas at graduation shows a substantially larger increase after 1994.

In the past, it was often said that roughly half of the foreign students stay in the United States after receiving doctorates in S/E fields. Figure 2 suggests that this was true but that now the appropriate shorthand expression would be to say that roughly two out of three stay.

**Figure 2. Foreign Students Receiving S/E Degrees from U.S. Universities
Who Were in the United States Two Years After Graduation, 1989 to 1999**
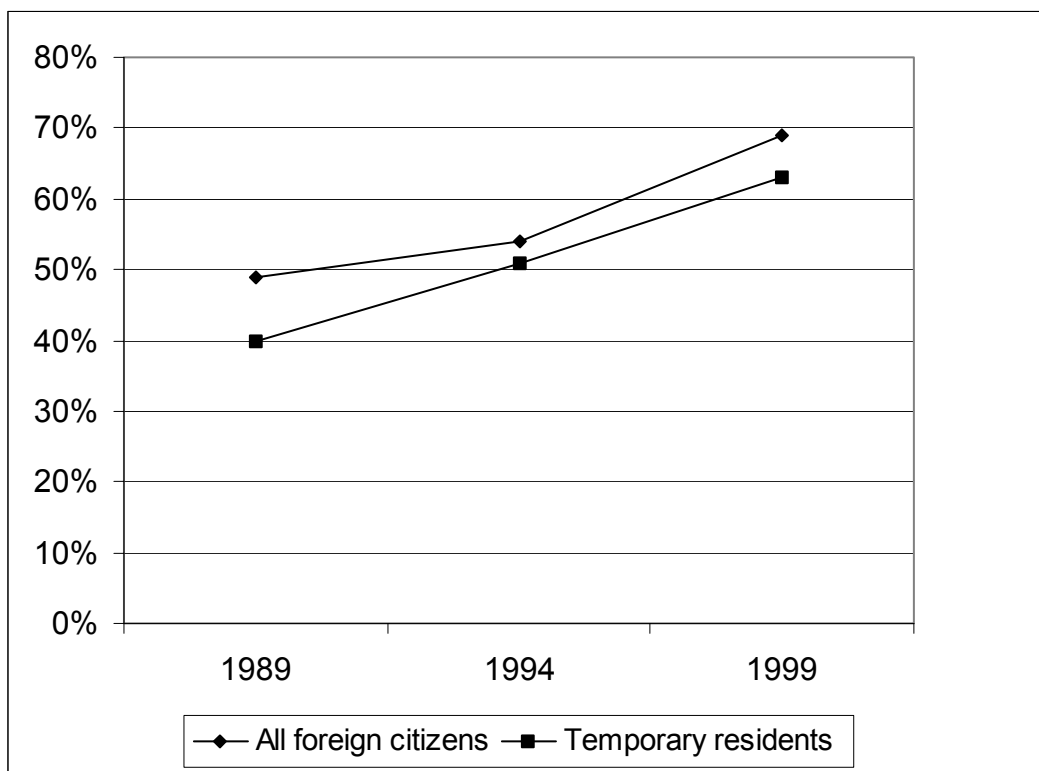
Note: The estimates for 1989 include persons graduating one or two years prior to the date shown, but this has little impact on the estimates.

Source: Oak Ridge Associated Universities.

All the stay rates reported above refer to a date about two years after graduation. Previous reports by the author emphasized the stay rate four to five years after graduation. Table 4 shows similar data for the most recent cohort available, the doctorate recipients of 1994 and 1995. The stay rate observed in 1999 for the 1994 and 1995 classes is significantly lower than the 1999 stay rate reported for the 1997 doctorate recipients reported earlier in Table 1. There seem to be two plausible explanations for this. One is that the stay rate increased sharply sometime after 1995. To the extent that this was caused by increased demand for foreign S/E doctorates in the United States, the increased demand must have had little impact on doctorates who had not graduated very recently. Data support this interpretation. For example,

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immigration law was changed and there was a sharp increase in visas granted to temporary workers. In particular, H1B visas were expanded with the express aim of helping high-tech industries in the United States. H1B visas awarded increased from 117,574 and 144,458 in 1995 and 1996 respectively to 240,947 in 1998.[2]

Table 4. Percentage of Temporary Residents Receiving Ph.D.s in 1994 or 1995
Who Were in the United States, 1996 to 1999

Degree Field	Foreign Doctorate Recipients	Percent in the United States			
		1996	1997	1998	1999
Physical science	2,347	64	59	59	58
Mathematics	817	50	50	47	46
Computer science	699	62	63	63	63
Agricultural science	813	38	36	36	35
Life science	2,091	56	53	52	52
Computer/EE engineering	1,365	63	63	63	62
Other engineering	3,666	55	54	54	56
Economics	975	27	27	27	26
Other social science	1,219	32	31	30	29
Total, all S/E fields	**13,992**	**53**	**51**	**51**	**51**

Source: Oak Ridge Associated Universities.

A second possible explanation for at least part of the lower stay rate of the 1994/95 cohorts is the reduced proportion of students from China in those cohorts. To explore that possibility, one first needs to review how the stay rate varies by country. Table 5 indicates that stay rates continue to vary more by country than by discipline. China, India, Nigeria, have the highest stay rates and these rates are about four to five times higher than the countries with the lowest stay rates, South Korea, Indonesia, and Brazil.

These country contrasts have been quite stable during the 1990s. Several prior reports placed China and India with the highest stay rates and South Korea and Brazil with the lowest stay rates. Also showing stability are the stay rates for Japan (still quite low) and the United Kingdom (still above average). If one were to look for individual countries changing rates during the 1990s perhaps the most notable would be China, India, Germany and Canada which all showed increases in rates. Among these both Germany and Canada previously had below average rates but now all four countries show above average rates in Table 5.[3]

Table 5 shows stay rates for several countries and country groups for which estimates were not previously available. The grouping "Other Europe, East" includes countries making up the former USSR and its satellites. The stay rate for "Other Europe, East," 69 percent, is well above the average for all countries. Colombia (29 percent) and Chile (26 percent) join Mexico and Brazil as Latin American countries with stay rates well below the average.

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[2]1998 Statistical Yearbook of the Immigration and Naturalization Service, Table 39.
[3]See Finn, 2000, for country specific stay rates in earlier years.

Table 5. Temporary Residents Receiving S/E Doctorates From U.S. Universities In 1994 or 1995 Who Were in the United States, 1996 to 1999

Country of Origin	Foreign Doctorate Recipients	1996	1997	1998	1999
China	1,649	89	90	92	91
Taiwan	2,268	45	42	41	42
Japan	233	30	29	27	27
South Korea	1,943	23	18	17	15
Other East Asia	391	27	26	27	27
India	1,995	88	88	88	87
Iran	198	60	61	62	61
Israel	121	42	39	34	31
Turkey	252	46	47	43	44
Other West Asia	981	44	44	43	44
Australia	85	43	40	39	34
Indonesia	119	13	12	15	16
New Zealand	29	51	63	67	63
Other Pacific/Australia	103	68	63	64	66
Egypt	157	38	40	39	37
Nigeria	50	86	87	87	85
South Africa	50	35	39	40	40
Other Africa	542	47	45	45	42
Greece	276	51	51	50	49
United Kingdom	140	61	63	61	60
Germany	262	47	49	50	53
Italy	106	34	39	40	37
France	142	49	47	49	47
Spain	87	33	29	35	34
Other Europe, East	283	72	70	70	69
Other Europe, West	338	42	41	41	39
Canada	430	55	54	55	55
Mexico	223	27	29	29	31
Argentina	67	49	48	46	45
Brazil	255	22	21	21	21
Chile	57	26	24	24	26
Colombia	66	27	28	27	29
Peru	37	74	71	71	66
Other Central South America	254	48	46	44	49
Total, all countries	**14,189**	**53**	**51**	**51**	**51**

Source: Oak Ridge Associated Universities.

Table 5 indicates that China's stay rate for temporary visa doctorate recipients, 91 percent, the highest of any country and well above the total stay rate of 51 percent. It also shows that only 1,649 of the doctorate recipients in Table 5 were from China. However, we know from Figure 1 that in the three previous years, 1991 to 1993, fully 24 percent of all temporary residents receiving S/E doctorates from U.S. universities were from China. This suggests a simple way to estimate the impact of having converted a large number of Chinese students from temporary to permanent visas prior to receipt of the doctorates in 1994 and following years.

Suppose that a new table were created that was identical to Table 5 except that the number of doctorate recipients from China and the Total were both increased by a number large enough so that Chinese students represented 25 percent of the total as they had in the three previous years. Such a table would show actual stay rates for each country, but the total stay rate would be hypothetical as it would give greater than the actual weight to the high Chinese stay rate. Such a table was constructed but is not shown because it is merely a hypothetical calculation. However, it indicates the total stay rate shown in Table 5 would increase from 51 to 57 percent if China were given the same weight it had in the three previous years.

This hypothetical stay rate of 57 percent for doctorates graduating four to five years prior to 1999 is exactly half way between the real stay rate for those doctorates in 1999 (Table 5) and the stay rate for 1997 doctorate recipients in 1999 (Table 1). Now, we can return to the question, Why is the 1999 stay rate only 51 percent for those who graduated in 1994/1995, while it is much higher, 63 percent, for those who graduated in 1997? The answer would appear to be that half of the difference (from 51 to 57 percent) is accounted for by the fact that in 1994 and 1995 many Chinese students had converted to permanent visas prior to graduation, thus depressing the total stay rate for temporary residents.

The observed increase in the total stay rate was due either to increased stay rates of individual countries or to changes in the relative mix of countries with quite different stay rates or some combination of these two. Following this line of reasoning the remaining half (from 57 percent to 63 percent) is unaccounted for and is likely due to higher stay rates in some or all of the countries shown in Table 6. However, the proportion of all temporary residents who are from China is only one aspect of the country mix. During the period from 1994/1995 to 1997, there was a dramatic increase in the proportion of temporary residents from China, but there were also smaller changes in the proportion of temporary resident doctorate recipients from other countries. To estimate the effect of all these shifts another hypothetical calculation was made, this time using the stay rates observed for the 1994/1995 cohorts in 1999 but weighted using the country proportions observed for the 1997 cohort. This produced a hypothetical 1999 stay rate of 56 percent as opposed to the actual 51 percent rate for that cohort in 1999. The 63 percent stay rate observed for the 1997 cohort in 1999 was higher still. When we looked only at the behavior of Chinese students it seemed that about half of the difference between the 1999 stay rates for the two cohorts could be explained by the shifting mix of doctorate recipients from China vs. other countries. However, with a more complete analysis of the shifting mix of all countries, it can be said that nearly half (the range from 51 to 56 percent) of the difference in stay rates between the two cohorts is due to the shifting mix of countries, while slightly more than half (the range from 56 to 63 percent) is due to changes in the stay rates of individual countries or country groups examined here.

We don't have country specific rates for the 1997 cohort, so we can't say which ones went up the most.

Longer Term Stay Rates

Previous tables reported on stay rates for doctorate recipients either 2 years or 4 and 5 years after graduation. The stay rates for the classes of 1994 and 1995 in 1999 in Table 4 were rather stable over time, that is, they did not show any discernable trend upward or downward during the 1996 to 1999 period. However, this is a fairly short period after their graduation. There is nothing in the data presented

so far that would address the issue of whether the foreign doctorate recipients leave in substantial numbers after acquiring several years of experience in the United States. This is addressed in Table 6. It shows stay rates for temporary residents receiving doctorates from U.S. universities in 1989. The stay rate overall is marginally lower than for those who graduated in 1994 and 1995 (Table 4). What is interesting, however, is that the stay rate after 10 years is nearly identical to the stay rate after 5 years, 50 vs. 48 percent. Given measurement error and sampling error, it is best to conclude there is no clear trend in Table 6, rather the stay rate stayed in a very narrow range from 48 to 50 percent. An early study found similar results with a much older cohort. [Finn, 1998] Stay rates seem remarkably stable for a given cohort as that cohort ages.

Table 6. Percentage of Temporary Residents Receiving Ph.D.s in 1989 Who Were in the United States, 1994 to 1999

Degree Field	Foreign Doctorate Recipients	Percent in the United States					
		1994	1995	1996	1997	1998	1999
Physical science	1,012	59	60	60	61	59	60
Engineering	1,940	51	50	51	51	52	52
Life science	742	49	48	50	49	52	52
All other sciences	1,758	39	39	40	40	40	41
Total, All S/E	**5,452**	**48**	**48**	**49**	**49**	**49**	**50**

Source: Oak Ridge Associated Universities.

While the stay rate for the class of 1989 was in the range of 48 to 50 percent from 1994 to 1999, this does not mean that there was little international migration of these doctorate recipients in the first decade after their graduation. Some who left the United States returned to live here and others left only after acquiring some postdoctoral experience. It is difficult to characterize the movements of persons who spent only part of the 1990's in the United States. However, we can measure the proportion who were here continuously, who paid U.S. Social Security and/or income taxes every year during the 10-year period, 1990-1999.

The tax data used for this report were used to tabulate the number in a group who paid taxes on at least $5,000 in earnings in 1999 and in several previous years. These data were also used to tabulate the number who had at least $5,000 in earnings in any one of the 10 years from 1990 to 1999. The extent that the proportion paying taxes at least one year out of the 10 exceeds the proportion paying taxes in 1999 provides a measure of return migration.

An examination of raw, i.e., unadjusted data, suggests that the stay rate for the class of 1989, which was 50 percent in 1999, would be 26 percent higher if the rate were to represent the proportion who had worked in the United States for at least one out of the 10 years. This suggests about 63 percent worked at least one year in the United States. Or put another way, for every four from the class of 1989 who were here in 1999, there was one more who had worked here but was no longer here in 1999.

TECHNICAL APPENDIX

This appendix provides information about the data and methods used to produce the results described in this report.

Sources of Data

This project was discussed carefully with staff of the National Opinion Research Center (NORC), the National Science Foundation (NSF), and the Social Security Administration to ensure that the methods chosen would comply with each organization's policy regarding the confidentiality of data on individuals. Data for the report pertain almost exclusively to a set of 99 groups of Ph.D. recipients who received S&E degrees from U.S. universities in 1989, 1994-1995, and 1997.

Our method started with responses to the NSF Survey of Earned Doctorates for the years of interest. This survey is not a sample survey but rather a complete census of new doctorate recipients in the United States, administered at or near the time that they complete their doctorates. Among the questions asked of these persons are country of citizenship, degree field, and post-graduation plans. Answers to these questions were used to define and identify groups for which stay rates were estimated (e.g., temporary residents graduating in 1994-1995 with a degree in economics). The NORC staff then prepared a diskette containing the birth years and Social Security numbers of the persons in each of these groups. In most cases, all the persons with the traits used to define the group were included. However, a sample was used in most cases where the total in the group was greater than 400 persons. In total, groups of foreign citizens containing a total of 21,795 persons were identified. In addition, 22 groups of U.S. citizens containing a total of 7,000 persons were identified. These were used to help make adjustments, if necessary, to raw data received from the Social Security Administration.

If no adjustments were to be made the stay rate would be the proportion in a group that was recorded by the Social Security Administration to have paid taxes on at least $5,000 in earnings. For example, one group consisted of 500 persons from China who were shown by the NORC to have received doctorates from U.S. universities in 1994 or 1995. The Social Security Administration found that 3 of these 500 had Social Security numbers that were invalid and 9 more had birth years reported by the NORC that conflicted with the birth year recorded at the Social Security Administration. Because birth year differences might signify that an invalid Social Security number was recorded at the NORC these cases were not used. That left 488 with presumed valid Social Security numbers. The Social Security Administration reported that 434 of the 488 individuals were recorded as having earned $5,000 or more in 1999. This can be used to calculate a stay rate of 434/488 or 90 percent. Because this is a group statistic and no one outside of the Social Security Administration saw any individual earnings or tax data, the confidentiality of all the individuals in the group was preserved.

As mentioned, Social Security Administration staff first checked to identify persons for whom the Social Security numbers provided were invalid. Also, they compared the year of birth provided for each Social Security number with the year of birth in the Social Security files for the person with that number. They then excluded from any tabulations persons with invalid numbers and persons for whom the birth years differed by more than 1 year. The primary concern that led to this birth year screen was the possibility that a Social Security number reported on the Survey of Earned Doctorates might be incorrect, yet would be treated by the Social Security Administration as valid if it was identical to one of the millions of numbers in the system. By requiring the birth year to match or be off by no more than one year, probably more than 95 percent of any such false matches were eliminated. Only 2.1 percent of U.S. citizens and 2.65 percent of foreign citizens had birth years that did not match within one year. A failure to match birth years in 2 to 3 percent of cases is not surprising since neither organization has 100 percent accuracy recording birth year. As for as the difference between the United States and foreign citizens, we postulate two distinct reasons. One is that foreign citizens sometimes write numbers differently or interpret

questions differently. Another is that some foreign citizens do not have Social Security numbers but may have reported similar numbers issued by their universities to students who don't have and don't want to get Social Security numbers. Insofar as the second reason holds, the difference between the U.S. rate of false matches (2.1 percent) and the foreign rate (2.65 percent) could be used as an indication of false matches that made it through the screen up to that point. Persons whose birth dates matched or were off by no more than one year were treated as having valid Social Security numbers. Since there are about 90 possible birth years (e.g., 1910 to 1999) that describe nearly all persons in the Social Security system in 1999, we conclude that a social-security-like number or a fake Social Security number would make it through the birth year screen with a chance of only about 3 out of 90, i.e., a probability of less than 3 percent. However, the chance of an invalid number making it through our screen is less than this. Many 9-digit numbers do not match because that number has not yet been issued to a person as a unique Social Security number. We did not carry this further after concluding that the possibility of false matches in our sample is quite small, surely less than 3 percent.

After screening out invalid Social Security numbers and numbers without birth years that matched (or were off by no more than one year), the Social Security Administration staff made an initial set of computer tabulations by calculating for each group the proportion with earnings of $5,000 or more in each year from 1994 to 1999. This produced no groups where problems of confidentiality occurred. The practical application of the Social Security Administration's confidentiality rules meant that it would report no proportion if a group had a calculated proportion of 100 percent or 0 percent as this would permit the identification of individuals by persons who could match Social Security numbers with names (e.g., the NORC staff who prepared the groups sent to the Social Security Administration). Further, to be safe, the Social Security Administration staff would not calculate a proportion if all but three persons in a group had earnings of $5,000 or more.

The decision to use a threshold of $5,000 in Social Security covered earnings as the basic unit of measurement was somewhat arbitrary. Any positive level of such earnings would presumably signify employment in the United States. However, if any positive Social Security covered earnings were used instead of the higher threshold of $5,000, then persons who earn a few thousand dollars for a speech or a very short consulting assignment would be counted as residing in the United States that year. Doctorates can work for low wages and a few do. However, even at the minimum wage a person would earn more than $10,000 per year. A $5,000 threshold is high enough to capture nearly all that worked in the United States for more than a few weeks. Moreover, we can be positive that this threshold captures everyone who worked in the United States for most of the year.

One reason for missing or invalid Social Security numbers is data error. Respondents to the Survey of Earned Doctorates may fail to write down their numbers or may record their numbers incorrectly, or coders at the National Research Council (which managed the surveys until 1997) may make errors. If we were confident that other reasons were of no importance, we would not make any adjustments to account for missing Social Security numbers. However, we believe that sometimes Social Security numbers are missing because foreign graduates did not have Social Security numbers, even though the vast majority has them. One of the reasons so many have Social Security numbers is because banks and universities use Social Security numbers as identification numbers. It is possible for students to go through graduate school without Social Security numbers, however, since many universities will issue a similar 9-digit ID number to foreign students who don't want to get U.S. Social Security numbers. These often start with the number 9, a number the Social Security Administration never uses for the first digit of a true Social Security number. Many of the invalid Social Security numbers started with a 9, so it appears students were confused and thought they were Social Security numbers. But there were also a significant number of graduates for whom no Social Security number was recorded by the National Research Council and a few that were never issued by the Social Security Administration. Table A-1 shows how the proportion missing valid Social Security numbers varies by year of graduation and degree field. To put this in

context, note that 3.9 percent of the U.S. citizens in the sample were also missing valid Social Security numbers, and that this figure varied little by year of graduation or degree field.

Table A-1 shows that the highest percentages missing valid Social Security numbers were observed among the "Other social science" graduates. The percentage missing valid Social Security numbers was below average in Physical science, Mathematics and Engineering. Detailed data not shown here also indicate that doctorate recipients from the countries with above average stay rates tend also to have valid Social Security numbers more often average. Foreign doctorate recipients tend to have higher proportions missing Social Security numbers than their U.S. counterparts, and this is especially true among categories of the foreign-born where relatively low proportions of those with Social Security numbers have reported earnings to the U.S. Social Security Administration.

**Table A-1. Percent of Sample Missing Valid Social Security Numbers
at Graduation for Foreign Citizens, by Year of Graduation**

Degree Field	1994-1995 Temporary Residents	1997 Temporary Residents	1994-1995 Permanent Residents
Total, All S/E	**6.0**	**5.0**	**3.0**
Physical science	4.6	4.4	1.9
Mathematics	4.9	3.6	1.4
Computer science	5.0	7.7	3.2
Agricultural science	8.9	7.4	4.5
Life science	8.5	4.1	2.5
Computer/EE engineering	5.0	3.3	3.8
Other engineering	4.5	4.1	3.1
Economics	7.5	7.7	5.8
Other social science	9.5	7.8	5.3

Source: Oak Ridge Associated Universities.

A low-case assumption was made that all persons with missing or invalid Social Security numbers left the United States after graduation and did not return to the United States in subsequent years. However, this is obviously extreme. At the other extreme, a high-case assumption was that the persons with missing or invalid Social Security numbers stayed to work in the United States at the same rate as others with the same characteristics (year of graduation, degree field, country of citizenship). Mid-case estimates, reported in the body of this report, are always the average of the high and low cases. Thus, in the mid-case estimates, the stay rate for those with missing numbers is half the stay rate for those with valid Social Security numbers in the same group. Making this adjustment had the result of reducing the stay rate of by nearly 1.4 percentage points, for both the 1997 and the 1994/1995 cohorts in 1999. This is so small that changing the assumptions mentioned above, for example using something closer to the high or low extreme, would have very little impact on estimated stay rates. Of course, some detailed estimates would be affected more or less than the average. The estimate with the greatest proportion of missing or invalid social security numbers is that for doctorate recipients from Canada. The estimated stay rate for Canadians in Table 5 would be 4.3 percentage points higher if no adjustment had been made for missing and invalid numbers. This is an extreme case. All others were adjusted by less than 3 percentage points.

After adjustment for missing Social Security numbers, the proportion paying taxes on at least $5,000 in earnings covered by Social Security could be interpreted as a stay rate. This would be valid if we could

assume that all doctorate recipients staying in the country pay Social Security taxes on at least this much in earnings. However, for any large group of doctorate recipients residing in the United States, it is likely that the percent paying taxes on at least $5,000 in income is less than 100. The principal reasons would be non-employment, part-time or part-year employment. Also, an entrepreneur might forgo a salary during the start-up of a business. Further, if we are examining data for persons receiving doctorates several years earlier, at least a few will not be paying taxes because they have died in the interim. Thus, adjustments were made for death and for the possibility of residing in the United States without earning $5,000 or more.

Adjustment for Death

Death rates of U.S. citizens were estimated by using the age-specific death rates recorded by the TIAA insurance company.[4] This adjustment raises stay rates only marginally because death rates for people under age 40 are very low and because, for most of our estimates, only a few years elapsed between receipt of doctorate and year of estimated stay rate.

Adjustment for Residents Earning Less than $5,000

The NSF's Survey of Doctorate Recipients was used to identify doctorate recipients who graduated during the period 1989 to 1996 and who responded to the survey that they had resided in the United States at periods after graduation that corresponded with periods after graduation used in this study for stay rates. For example, 1993 doctorate recipients who were in the United States in 1995 were used to estimate the proportion of temporary residents who were here two years after graduation but who earned less than $5,000 in 1995. To improve sample size this group was defined to include graduates from 1992 and 1994 as well so that the average date of graduation was 1993. To further reduce sampling error similar estimates were made using the 1997 survey and then the estimates for each of these two surveys were averaged. The resulting estimate was that 2.5 percent of persons receiving doctorates two years earlier earned less than $5,000 during an entire year even though they were in the United States that year. The stay rate estimates for 1997 temporary resident doctorate recipients were adjusted upward on the assumption that, like those in earlier years, about 2.5 percent would not have earnings of $5,000 even though they resided in the United States. Similar sets of estimates were constructed for the 1994-95 graduates residing in the United States in 1999: 3.2 percent of them had earnings below the threshold. Similar sets of estimates were constructed for the 1989 graduates residing in the United States in 1999: 2.9 percent of them had earnings below the threshold.

Effect of the Adjustments

The adjustments for missing and invalid Social Security numbers had the effect of lowering stay rate estimates slightly. The adjustments for death and for persons residing in the United States without earning as much as $5,000 in taxable income had the effect of increasing stay rates slightly. The net effect of these adjustments was to increase stay rate estimates–but only very slightly. For example, Table 1 shows a stay rate estimate for 1997 doctorate recipients in 1999. This increased from 62.2 percent to 62.8 percent (rounded to 63 percent in Table 1) because of the net effect of adjustments. Table 4 shows a stay rate estimate for 1994/95 doctorate recipients in 1999. This increased from 49.3 percent to 50.5 percent (rounded to 51 percent in Table 4) because of the net effect of adjustments. The effect of adjustments was somewhat greater for sub-categories such as degree field groupings. Taking Table 1 and 4 together there are 18 such estimates. The one most affected by adjustments was the estimated stay rate for recipients of life science doctorates in 1994/95. An unadjusted stay rate would have been 50 percent rather than the 52 percent reported in Table 4. As this was the largest change for any of the degree field groups adjusted in

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[4] These were published in National Research Council, 1989, p.114

the manner described it should be clear that the impact of these adjustments was small, even for sub-groupings of doctorate recipients.

There is an estimate at the end of the main body of this paper which address the issue of 1989 doctorate recipients who may have worked in the United States for a year or more but who were no longer in the United States after 10 years, i.e., in 1999. Unadjusted data were used to estimate that the 1999 stay rate of 50 percent "would be 26 percent higher if the rate were to represent the proportion who had worked in the United States for at least one out of the 10 years." In this instance it was judged that the data available from the Survey of Doctorate Recipients did not permit the type of adjustment made for other estimates in the report. Thus, an approximate estimate was made with unadjusted data. In light of the slight impact of adjustments demonstrated in the previous paragraph, the presentation of unadjusted estimates seems justified.

Non-Payment of Taxes

There was no adjustment made for foreign doctorate recipients who work in this country after graduation and had earnings in excess of $5,000 but did not pay either Social Security tax or U.S. income tax on those earnings. It is possible to work in the United States in a job that is not covered by Social Security. There are several states where some or all of the state employees are outside the Social Security System. Also, some on postdoctoral appointments do not pay Social Security taxes, and there may be other instances, e.g., some kinds of non-profit organizations. When the author of this report made stay rate estimates in earlier years he made an additional adjustment to account for the fact that some who earn $5,000 or more in the United States do not show up on the rolls of the Social Security Administration because they did not pay Social Security taxes on those earnings. This adjustment is no longer necessary or appropriate. The data received from the Social Security Administration for this report treated a person as having earned $5,000 or more if they paid either Social Security tax or U.S. federal income tax on at least that much. This almost completely solves the downward bias resulting when using Social Security tax payment alone. The vast majority of persons who are exempt from the payment of Social Security taxes are required to pay U.S. federal income tax on earnings in the United States.

To the extent that persons who are required to pay U.S. federal income taxes cheat and don't pay on at least $5,000 in earnings then the stay rates estimated in this report are biased downward. It appears that recent science and engineering doctorates do in fact pay their taxes, or at least they pay on more than $5,000 of income. This was checked by sending the Social Security Administration a group of 300 Social Security numbers of U.S. citizens who had earned doctorates in 1999 to 1991 period and who also completed a survey form for the 1995 Survey of Doctorate Recipients. This group consisted of respondents who indicated that they had not worked or conducted research abroad for a period of six months or longer when they responded to the 1995 Survey of Doctorate Recipients. While recent doctorate recipients might go abroad for reasons unrelated to work or research, the proportion of U.S. citizens who are recent recipients of S/E doctorates doing this can be expected to be very small. Thus, if U.S. citizens who are recent doctorate recipients all pay either Social Security or U.S. Income taxes then we would expect that virtually all of this group would be shown to have $5,000 or more in income. In fact, 95.2 percent of this group[5] did have such earnings. The difference between 95.2 percent and 100 percent is not likely tax cheating. If 3 percent were in the U.S. but not earning $5,000 and an additional 1 percent had died or gone abroad for reasons other than to work or do research, then this would account for 99 percent, leaving less than 1 percent to be explained by tax evasion.

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[5] The group was reduced from 300 to 294 because six of the doctorate recipients had birth dates on file at the Social Security Administration that did not match the birth dates recorded by the Doctorate Records project. For these six there was an error somewhere in either the recorded birth date or the recorded social number and for this reason they were not used.

One might argue that this example doesn't necessarily apply to foreign citizens as well. However, the reason that both groups would show little evidence of illegal tax evasion is that the vast majority of recent doctorate recipients are not even tempted. When income comes from wages, employers are required to file W-2 forms with the Internal Revenue Service. Thus, there is little opportunity to avoid paying taxes. There is one opportunity, however, for legal tax avoidance that is open to some foreigners but not U.S. citizens. The United States has tax treaties with most foreign nations, and some of these treaties allow foreign citizens to teach or conduct research in the United States for up to two or three years without being subject to U.S. income tax.

The issue of legal exemption from U.S. income taxes by reason of tax treaty is very complicated. Further complicating the issue for purposes of this paper is that exemption from U.S. income tax would not affect the estimates in this report unless the individual in question is exempt form our Social Security taxes as well. There is evidence that most postdocs pay Social Security taxes[6]. There are very few other types of employment engaged in by recent S/E doctorates where the payment of Social Security taxes is not required. A review of the many treaties indicates the following:

- None of the treaties apply to persons employed outside the university/non-profit sectors.
- None of the treaties exempt foreign workers from U.S. Social Security tax.
- Most of the treaties exempt income only for two years in the United States.
- Many of the treaties apply only to teachers; the rest only to teachers or researchers in non-profit and/or government labs.
- Some countries have no such treaty with the United States.
- The person must be a tax resident of the home country.
- Many of the treaties link exemption for teachers/researchers to previous exemptions for graduate study in the United States and limit the total to five years.[7]

We conclude that the stay rates presented in this report are biased downward because a few foreign doctorate recipients can legally avoid U.S. tax liabilities. While the direction is clear it seems that the impact is very small, and further that it would be largely confined to the stay rates of 1997 graduates in 1999. We can't put an exact value on it. However, it seems very unlikely that the 63 percent stay rate estimated for the 1997 cohort in 1999 would increase to more than 65 percent if it were possible to make an accurate adjustment for this factor. For the older cohorts, it seems certain that most would have exhausted any exemption to which they may have been entitled, and that any underestimate of stay rates is likely to be in the range of the round-off error, less than one percent.

Sampling Error

When the population number for a group was no greater than 500, sampling was not used and the estimates were obtained by sending the Social Security numbers of all persons in the group to the Social Security Administration. However, samples (usually 400 or 500) were selected when the number was very large. In such cases there is a probability of sampling error even though the sample is relatively large. In the tables below we show the 95 percent confidence interval around key estimates in this report. The "mid" value shown in these tables corresponds to the estimated 1999 stay rate shown in the body of this report, after rounding to the nearest percentile.

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[6] Finn, et.al., 1995, p.8
[7] Singer, 1996 and 1999

Table A-2. Confidence Interval for Estimates of Percentage of Temporary Residents Receiving Ph.D.s in 1997 Who Were in the United States in 1999

Degree Field	Foreign Doctorate Recipients	Sample Size	95 Percent Confidence Interval		
			Low	Mid	High
Physical science	1,232	385	68.8	73.2	77.6
Mathematics	416	416	66.1	66.1	66.1
Computer science	315	315	73.1	73.1	73.1
Agricultural science	351	351	46.0	46.0	46.0
Life science	1,283	389	64.5	69.1	73.7
Computer/EE engineering	649	384	77.4	81.3	85.2
Other engineering	1,746	385	54.9	59.8	64.7
Economics	449	449	34.0	34.0	34.0
Other social science	500	500	36.6	36.6	36.6
	6,941	3,444	59.6	62.8	66.1

Source: Oak Ridge Associated Universities

For Table A-2 a confidence interval was calculated using standard statistical procedures, but only for the four degree-field groupings where sampling was used. For the other five degree field groupings the "confidence interval" shown is simply the estimate restated, and thus the difference between the high and low end of the interval is zero. There is no sampling error because no sampling was used in these groups. The last line shows a confidence interval that was computed as the weighted average of the confidence intervals for the various degree field groups shown in the table. The resulting confidence interval for the total stay rate of 1997 temporary resident doctorate recipients in 1999 is fairly tight, plus or minus about 3.25 percent.

Table A-3 was constructed in a similar manner. As this table indicates, sampling was used only for 6 countries or country groups, because all other countries accounted for fewer than 500 doctorate awards in 1994 and 1995 combined. While the estimates for these smaller countries are not subject to sampling error, they are in some cases based on quite small numbers of degree awards and the estimate stay rates may have been quite different if different degree award years had been chosen instead.

**Table A-3. Confidence Interval for Estimates for the Percentage of Temporary Residents
Receiving Ph.D.s in 1994 or 1995 Who Were in the United States in 1999**

Country of Origin	Foreign Doctorate Recipients	Sample Size	95 Percent Confidence Interval		
			Low	Mid	High
China	1,649	488	88.5	91.1	93.6
Taiwan	2,268	488	38.0	42.4	46.8
Japan	233	233	26.8	26.8	26.8
South Korea	1,943	488	12.0	15.1	18.3
Other East Asia	391	391	26.9	26.9	26.9
India	1,995	486	84.5	87.5	90.4
Iran	198	198	61.4	61.4	61.4
Israel	121	121	30.9	30.9	30.9
Turkey	252	252	43.7	43.7	43.7
Other West Asia	981	482	40.0	44.4	48.9
Australia	85	85	34.0	34.0	34.0
Indonesia	119	119	16.4	16.4	16.4
New Zealand	29	29	63.3	63.3	63.3
Other Pacific/Australia	103	103	65.9	65.9	65.9
Egypt	157	157	37.1	37.1	37.1
Nigeria	50	50	84.9	84.9	84.9
South Africa	50	50	39.7	39.7	39.7
Other Africa	542	280	36.5	42.2	48.0
Greece	276	276	49.1	49.1	49.1
United Kingdom	140	140	60.0	60.0	60.0
Germany	262	262	53.0	53.0	53.0
Italy	106	106	37.1	37.1	37.1
France	142	142	46.9	46.9	46.9
Spain	87	87	34.0	34.0	34.0
Other Europe, East	283	283	69.5	69.5	69.5
Other Europe, West	338	338	38.7	38.7	38.7
Canada	430	430	55.1	55.1	55.1
Mexico	223	223	30.8	30.8	30.8
Argentina	67	67	44.7	44.7	44.7
Brazil	255	255	21.1	21.1	21.1
Chile	57	57	26.1	26.1	26.1
Colombia	66	66	28.5	28.5	28.5
Peru	37	37	65.7	65.7	65.7
Other Central South America	254	254	48.9	48.9	48.9
Total, all countries	**14,189**	**7,523**	**48.7**	**51.1**	**53.5**

Source: Oak Ridge Associated Universities.

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REFERENCES

Finn, Michael G. <u>Stay Rates of Foreign Doctorate Recipients from U.S. Universities, 1997</u>, Oak Ridge, TN: Oak Ridge Institute for Science and Education, 2000.

Finn, Michael G. <u>Stay Rates of Foreign Doctorate Recipients from U.S. Universities, 1995</u>, Oak Ridge, TN: Oak Ridge Institute for Science and Education, 1998.

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

National Research Council, <u>Biomedical and Behavioral Research Scientists: Their Training and Supply</u>, Volume I, Washington, DC: National Academy Press, 1989

National Science Foundation, <u>Science and Engineering Doctorate Awards – 1999</u>, Arlington, VA (NSF 01-314).

Singer, Paula N. and Gary Singer, <u>Tax Treaty Benefits for Foreign Students and Scholars</u>, Norwood, MA: Windstar Technologies, Inc. 1999

Singer, Paula, "Payments to Foreign Students and Scholars Involve Complex Withholding Rules," <u>Journal of Taxation of Exempt Organizations</u>, September/October 1996, vol.8, no.2.

U.S. Immigration and Naturalization Service, <u>Statistical Yearbook of the Immigration and Naturalization Service</u>, 1998, United States Government Printing Office: Washington, D.C. 2000