

Stay Rates of Foreign Doctorate Recipients from U.S. Universities, 2001

Prepared by:

Michael G. Finn
Science and Engineering Education Program
Oak Ridge Institute for Science and Education

November 2003

All opinions expressed in this paper are the author's and do not necessarily reflect policies and views of the U.S. Department of Energy (DOE) or the Oak Ridge Institute for Science and Education (ORISE).

This document was prepared for the Division of Science Resources Studies of the National Science Foundation by ORISE through an interagency agreement with DOE. ORISE is managed by Oak Ridge Associated Universities under DOE contract number DE-AC05-00OR22750.

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 include the following:

- More than two-thirds (71 percent) of foreign citizens who received science/engineering doctorates from U.S. universities in 1999 were in the United States in 2001.
- The two-year stay rate has increased substantially. It was only 49 percent in 1989 and increased fairly steadily to 71 percent in 2001.
- In 1999 the number of foreign citizens who earned S/E doctorates in the United States and stayed here at least two years was about 3,600 higher than it had been 12 years earlier. Approximately 45 percent of this increase came from an increase in the number of doctorates awarded. The other 55 percent came from an increase in the stay rate of the new foreign doctorate recipients.
- A stay rate for only those foreign doctorate recipients on temporary visas observed two years after graduation (i.e., excluding those on permanent visas at graduation) was estimated as well. This rate increased from 41 percent in 1989 to 68 percent in 2001.
- Among discipline groups, the highest stay rates were recorded for computer/electrical and electronic (EE) engineering, computer science, and the physical sciences. The stay rates in economics and the other social sciences were 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 (96 percent) and India (86 percent) are very high, while Taiwan (40 percent) is relatively low, and Korea (21 percent) is very low.
- Stay rates in 2001 were lower for earlier cohorts. The stay rate for 1996 foreign recipients of S/E doctorates was 65 percent. It appears that the factors causing increasing stay rates operate primarily on the new graduates; older cohorts continue to stay at rates nearly equal to the stay rates they experienced two years after graduation.
- Stay rates were also estimated for the Class of 1991. About 58 percent were in the U.S. in 2001. A larger proportion, about 72 percent, paid taxes on U.S. earnings during at least one year out of the 10 years following their graduation. This indicated that for every four who were here in 2001, there was almost one more who had worked here but was no longer here in 2001.

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 represents 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., 2001. Each line in the 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 foreign 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, he or she was 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 is described in detail in the Technical Appendix. However, the effect of these adjustments is quite small. The stay rates reported here are very close to the rates that can be deduced from tax payments with no adjustments.

Stay Rates of Recent Graduates

Table 1 provides stay rates for 1999 foreign doctorate recipients in 2000 and 2001. This table contains information on all foreign students, including some who had permanent resident visas at the time of graduation. Table 1 indicates that the 2001 stay rate for S/E doctorates is quite high at 71 percent overall. The 2001 stay rates in the agricultural and social science are lower, around 50 percent. The highest stay rates were recorded in the physical sciences, 79 percent in 2001, and in computer/EE engineering, 80 percent in 2001.

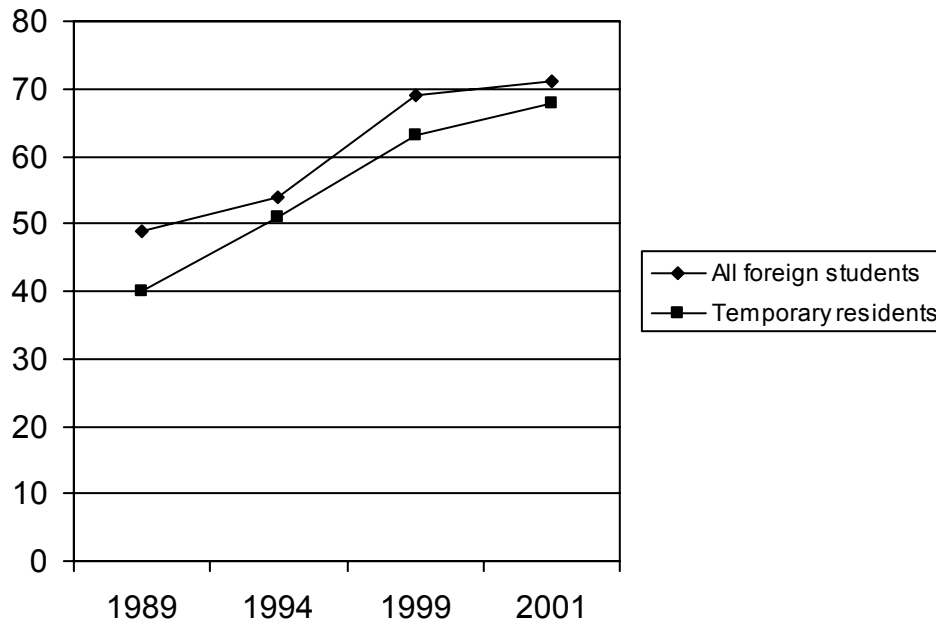
**Table 1. Percentage of Foreign Students Receiving Ph.D.s in 1999
Who Were in the United States, 2000 to 2001
(includes students on temporary and permanent visas)**

Degree Field	Foreign Doctorate Recipients	Percent in the United States	
		2000	2001
Physical science	1,615	80	79
Mathematics and computer sciences	821	76	75
Agricultural science	487	54	50
Life science	2,058	79	77
Computer/EE engineering	711	83	80
Other engineering	1,807	74	73
Economics	553	47	46
Other social science	718	54	55
Total, all degree fields	8,770	73	71

Source: Oak Ridge Associated Universities.

The stay rate shown in Table 1 is a new high. However, during the decade of the 1990s there was a fairly steady increase in the stay rate. As Figure 1 illustrates, the stay rate for all foreign S/E students has increased from 49 percent in 1989 to 71 percent in 2001.

Figure 1. Foreign Recipients of S/E Doctorates Who Were in the United States Two Years After Graduation, 1989-2001



The substantial increase in stay rates from 1989 to 2001 was accompanied by a substantial increase in the number of doctorates granted to foreigners by U.S. universities. Table 2 reports the number of S/E doctorates that U.S. universities awarded to both U.S. citizens and citizens of foreign countries in 1987 and 1999. These dates are two years prior to the dates shown in Figure 1 because that figure shows the stay rate two years after graduation. Table 2 shows an increase in doctorates awarded to foreign students from 5,557 in 1987 to 8,888 in 1999. Since Figure 1 gives the percentage staying in 1989 and 2001 as 49 and 71 percent, respectively, we can calculate how many foreign doctorate recipients stayed from each class. This calculation shows 2,723 staying from the class of 1987 and rising to 6,310 from the class of 1999.

If the number of doctorate awards grew as stated above but the stay rate had remained at the 1987 level of 49 percent, then the number of foreign doctorates would not have risen to the actual level for the class of 1999, 6,310, but rather to only 4,355. The increased stay rate can be said to have resulted in an increase amounting to the difference between these two figures, $6,310 - 4,355 = 1,955$. That is, increased stay rates brought the United States an additional 1,955 S/E doctorates.

Table 2. Science and Engineering Doctorates Awarded by U.S. Universities, by Citizenship Status, Selected Years, 1987 to 1999.

Citizenship Status	1987	1992	1997	1999
Temporary visa	4,468	8,092	7,499	7,236
Permanent visa	1,089	1,383	2,280	1,652
Total, foreign citizens	5,557	9,475	9,779	8,888
U.S. citizens	12,966	14,559	16,119	15,800

Source: National Science Foundation, Science and Engineering Doctorate Awards: 1996, and Science and Engineering Doctorate Awards: 2000, (NSF 97-329) and (NSF 02-305).

Had the stay rate remained at 49 percent, there would have been an increase resulting from the increased number of doctorates awarded to foreigners. Table 2 shows an increase from 1987 to 1999 of 3,331. If only 49 percent stayed this would have brought the United States 1,632 S/E doctorates.

Thus, the period between 1987 and 1999 saw a substantial increase in the number of foreigners earning S/E doctorates and staying in the United States after graduation. The total annual increase in doctorate stayers for the most recent year examined, 1999, was 3,577. Of this total increase about 45 percent came from an increase in the number of doctorates awarded, and about 55 percent came from an increase in the stay rate of new doctorate recipients.

The stay rate in 2001 was lower for persons who received their doctorates in earlier years. Table 3 shows that the stay rate for foreign students receiving doctorates in 1996 was 65 percent. Note however, that the stay rate for this class in 1998, two years after their graduation, was 66 percent. The stay rate for this class did not decline appreciably during the first five years after graduation. This is significant because many new doctorates take postdoctoral research appointments, but only a fraction of these are still in postdoctoral appointments five years after graduation. Since we observe only a small decline in stay rates during the first five years an assumption could be made that foreign doctorate recipients from U.S. universities routinely take regular employment in the United States after completing postdoctoral appointments.¹

¹ Although it seems appropriate to say that these doctorate recipients routinely transition from postdoctoral appointments to more regular employment in the United States, this doesn't mean that none leave. The stay rate would remain constant if a substantial number left in any given year and were replaced by others who had left earlier and had returned to the United States.

**Table 3. Percentage of Foreign Students Receiving Ph.D.s in 1996
Who Were in the United States, 1997 to 2001
(includes students on temporary and permanent visas)**

Degree Field	Foreign Doctorate Recipients	Percent in the United States				
		1997	1998	1999	2000	2001
Physical science	1,934	74	75	74	73	73
Mathematics	600	68	68	67	66	66
Computer science	467	72	72	70	70	70
Agricultural science	543	48	49	48	46	47
Life science	2,409	71	71	71	72	73
Computer/EE engineering	950	78	78	77	76	75
Other engineering	2,566	68	68	66	65	65
Economics	642	35	35	36	36	36
Other social science	872	49	50	50	51	49
Total, all fields	10,983	66	66	66	65	65

Source: Oak Ridge Associated Universities.

Table 3 also shows stay rates by degree field. The field differences are remarkably similar to the field differences shown for the 1999 cohort in Table 1. For example, agricultural and social sciences have below average stay rates, with economics having the lowest rate of all.

Long Term Stay Rates

Do foreign doctorate recipients leave the United States after staying here to gain work experience for a few years? The data presented so far indicate that stay rates don't fall appreciably during the first five years after graduation. Data in Table 4 indicate that this is true during the period that is 2 to 10 years after graduation as well. The 2001 stay rate for all S/E doctorates awarded by U.S. universities to foreign citizens in 1989, 58 percent, is somewhat lower than the stay rates of more recent classes. However, the stay rate did not decline appreciably during the period examined, 1993 to 2001. This provides additional evidence about how stay rates increased in the 1990s. The increase has occurred almost entirely because more recent graduates have higher stay rates. There is no evidence that stay rates for any given class tended to increase as time since graduation increased. This would seem rather obvious if one viewed all persons who leave the United States as having left for good. However, that is not the case. There is a certain amount of churning going on with respect to past classes of foreign graduates of U.S. universities. Some leave after staying here for a while, and these are largely replaced by others who return to the United States after living abroad for a while. Data on the foreign citizens who earned doctorates in the United States in 1989 give us some insight into this phenomenon.

**Table 4. Percentage of Foreign Students Receiving Doctorates in 1991
Who Were in the United States, 1993-2001
(includes students on temporary and permanent visas)**

Degree Field	Foreign Doctorate Recipients	Percent in the United States								
		1993	1994	1995	1996	1997	1998	1999	2000	2001
Physical science	2,115	69	69	67	67	68	69	69	69	69
Engineering	2,342	58	57	56	56	56	56	56	57	56
Life science	1,501	66	66	65	65	66	65	66	67	67
All other science	2,833	49	49	48	48	47	48	48	48	48
Total	8,791	59	59	58	58	58	58	58	59	58

Source: Oak Ridge Associated Universities.

An examination of raw, i.e., unadjusted data, suggests that the stay rate for the class of 1991, which was 58 percent in 2001, would be 23.5 percent higher if the rate were to represent the proportion who had worked in the United States for at least one year during the 1992 to 2001 period. This indicates that about 72 percent of the foreign citizens who received S/E doctorates from U.S. universities in 1991 worked in the United States for at least one year. Or put another way, for every four foreign students from the class of 1991 who were here in 2001, there was almost one more who worked here but was no longer here in 2001.

Stay Rates for Temporary Residents

The discussion above focused on the stay rate of all students who were foreign citizens at the time they received doctorates from U.S. universities. This definition includes both those who have temporary visas and those with permanent visas. Most discussions of foreign graduate students, however, refer only to those on temporary visas. For example, the *NSF Survey of Graduate Student Support and Postdoctorates in Science and Engineering* is a source of information on total and foreign student enrollment in graduate S/E programs. However, it defines foreign students to include only those on temporary visas and incorporates those on permanent visas together with U.S. citizens.

The temporary student visa definition of “foreign student” has worked well most of the time. However, during the 1990s special legal provisions were passed to grant permanent visa status to foreign students from China. Since China was the largest source country, this significantly reduced the number of foreign students, unless one used the broader definition that included permanent and temporary resident students. Also, since students from China had the highest stay rate, the fact that many Chinese students received permanent resident status while working on their doctorates tended to reduce the total stay rate for all countries if the temporary resident definition was used.

Notwithstanding the good reasons to define “foreign student” to include both those on permanent and temporary resident visas, there is value in the calculation of a separate stay rate for temporary residents. This conforms to the more typical definition of “foreign student.” Also, there are some historical statistics of stay rates by country of origin that were only produced for students on temporary visas, and a similar definition is needed to compare the data on recent cohorts with data from earlier cohorts. Thus, this section presents estimates of stay rates for foreign citizens on temporary visas at the time they received their doctorate degrees.

Table 5 shows the two-year stay rate for students on temporary visas who received doctorates in 1999. The overall stay rate shown for all S/E degree fields in Table 5 is 68 percent in 2001. This is only slightly less than the 71 percent stay rate for all foreign citizens during the same period shown in Table 1. Table 6 shows the 5-year stay rate for students on temporary visas when they received their doctorates in 1996.

**Table 5. Percentage of Temporary Residents Receiving Ph.D.s in 1999
Who Were in the United States, 2000 and 2001**

Degree Field	Foreign Doctorate Recipients	Percent in the United States	
		2000	2001
Physical science	1,322	78	75
Mathematics	435	72	71
Computer science	320	77	76
Agricultural science	436	50	45
Life science	1,517	77	74
Computer/EE engineering	591	80	77
Other engineering	1,525	71	70
Economics	484	42	42
Other social science	323	47	47
Total, all fields	6,953	70	68

Source: Oak Ridge Associated Universities.

**Table 6. Percentage of Temporary Residents Receiving Ph.D.s in 1996
Who Were in the United States, 1997 to 2001**

Degree Field	Foreign Doctorate Recipients	Percent in the United States				
		1997	1998	1999	2000	2001
Physical science	1,345	67	65	63	63	64
Mathematics	442	59	59	57	57	57
Computer science	375	67	66	65	65	64
Agricultural science	440	40	39	37	38	38
Life science	1,508	63	61	59	61	62
Computer/EE engineering	735	73	72	71	71	70
Other engineering	1,988	62	60	59	58	58
Economics	525	27	27	27	27	26
Other social science	571	37	35	36	35	33
Total, all fields	7,929	59	57	56	56	56

Source: Oak Ridge Associated Universities.

Stay rates vary considerably by country of origin, which is shown in Table 7. Table 7 is restricted to persons on temporary visas at the time the doctorate is received. This is why the total stay rate is only 56 percent in Table 7 as opposed 65 percent in Table 3. Table 7 also illustrates that four countries account for most of the foreign students receiving doctorates: China, India, Taiwan, and South Korea. Two of these, China and India, also have the two highest stay rates. The stay rate of India in 2001, 86 percent, is very high given that none of these were permanent residents at the time of graduation.

The 2001 stay rate for Chinese doctorate recipients in Table 7, 96 percent, almost seems too high to be true. However, there is reason to have confidence in this estimate. It depends on estimates and adjustments in very minor ways. The true stay rate must be close to this estimated stay rate because tax records showed that 1,190 out of 1,274, (or 93.4 percent) of Chinese citizens on temporary visas who received doctorates in 1996 paid U. S. taxes on at least \$5,000 in income in 2001. This was not based on a sample. The 1,290 persons for whom tax records were checked include all but about 5 percent of Chinese doctorate recipients. The 5 percent for whom earnings were not checked did not report a valid U.S. Social Security number to the Survey of Doctorate Recipients, or we failed to get a social security number and birth year match when the survey data were matched with Social Security Administration files. The method for producing these estimates is outlined in detail in the Appendix. It can be summarized briefly by stating that an unadjusted stay rate of 93.4 percent for Chinese on temporary visas was increased to 96 percent to account for the number who were estimated to have died during the five-year period and also for the number estimated to be present in the United States but not working enough during 2001 to earn \$5,000.

Not all of the large source countries for foreign students display high stay rates in Table 7. Taiwan's stay rate was only 40 percent in 2001, and South Korea's only 21 percent during the same period. Other countries with low stay rates include Indonesia (18 percent), Japan (24 percent), and Brazil (25 percent) in 2001. Other countries with above average rates in 2001 include Canada (62 percent) and Eastern Europe countries combined (77 percent).

The country-by-country variation in stay rates shown in Table 7 is similar to the patterns observed in previous studies of stay rates conducted by the author. Table 8 shows such a comparison for selected countries. For each of the classes examined in Table 8, students from China have the highest stay rate, and those from India have the second highest. Korea has the lowest stay rate every year, while Brazil and Japan have been the second and third lowest but have traded places at times. While the overall pattern in Table 8 is one of stability, it is noteworthy that the stay rate for Canadians has grown rapidly; it was well below average in 1992 and was above average in 1999 and 2001. Table 8 suggests that the overall trend of increasing stay rates was shared by most countries during this period. The United Kingdom and Taiwan are the only two countries in Table 8 where stay rates declined over the period from 1992 to 2001.

**Table 7. Percentage of Temporary Residents Receiving Ph.D.s in 1996
Who Were in the United States, 1997 to 2001**

Country of Origin	Doctorate Recipients	Percent in the United States				
		1997	1998	1999	2000	2001
China	1,345	93	94	94	95	96
Taiwan	1,044	46	44	42	41	40
Japan	131	24	23	24	24	24
South Korea	875	30	25	25	23	21
India	1,093	89	88	87	87	86
Other East Asia	94	59	57	52	52	51
Iran	73	76	73	71	70	70
Israel	61	54	55	53	55	51
Turkey	124	57	56	51	50	50
Other West Asia	215	41	39	36	37	39
Australia	32	47	47	44	37	37
Indonesia	66	19	18	19	19	18
New Zealand	28	71	60	60	60	56
Egypt	86	56	58	50	43	47
South Africa	41	45	40	37	40	43
Other Africa	244	51	49	48	46	47
Greece	108	52	52	51	52	53
United Kingdom	65	61	62	62	58	53
Germany	118	53	49	53	49	48
Italy	65	42	42	40	40	39
France	53	36	32	28	28	30
Spain	49	34	36	43	43	36
Other EU countries	150	40	39	35	39	38
Other Europe, East	200	74	76	74	74	77
Other Europe, West	57	49	49	49	55	48
Canada	215	57	60	61	61	62
Mexico	143	36	30	25	27	29
Argentina	52	55	49	49	53	57
Brazil	204	26	23	22	24	25
Chile	31	31	27	31	24	28
Colombia	31	35	35	28	31	35
Peru	22	62	57	52	46	41
Other Central South America	61	40	42	42	44	49
Country not specified	753	45	43	43	44	44
Total, all countries	7,929	59	57	56	56	56

Source: Oak Ridge Associated Universities.

Table 8. Percentage of Foreign Students on Temporary Visas Receiving Doctorates Who Were in the United States 4 to 5 Years After Graduation, Selected Years, 1992 to 2001

Country of Origin	1987/88 Doctorate Recipients in 1992	1990/91 Doctorate Recipients in 1995	1992/93 Doctorate Recipients in 1997	1994/95 Doctorate Recipients in 1999	1996 Doctorate Recipients in 2001
China	65	88	92	91	96
India	72	79	83	87	86
United Kingdom	na	59	56	60	53
Canada	32	46	48	55	62
Greece	44	41	46	49	53
Germany	na	35	38	53	48
Taiwan	47	42	36	42	40
Japan	17	13	21	27	24
Brazil	13	25	15	21	25
Korea	17	11	9	15	21
Average percentages, all countries	41	47	53	51	56

Source: Oak Ridge Associated Universities.

Conclusions

This paper documents a strong trend of increasing stay rates for foreign doctorate recipients in S/E fields. It also shows that the increase came about because successive cohorts stayed at increasingly higher rates, not because the rate increased for any given cohort of doctorate recipients over time.

U.S. universities increased the number of foreign doctorate recipients substantially during the period from 1987 to 1999. However, increasing stay rates contributed even more to the substantial increase in the number of foreigners who earn U.S. doctorates in S/E fields and stay in the United States after degree completion.

The stay rate varies considerably by country of origin. However, this paper does not speculate why this is so, or why the rate increased over time. In spite of this, one prediction seems safe to make. We should not expect an increasing stay rate to make as large a contribution to U.S. labor supply over future decades as it has in the past. Its upper limit is 100 percent.

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 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 89 groups of Ph.D. recipients who received S&E degrees from U.S. universities in 1991, 1996, and 1999.

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 1996 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. In total, groups of foreign citizens containing a total of 40,735 persons were identified.

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 either Federal income taxes and/or Social Security taxes on at least \$5,000 in earnings. For example, one group consisted of 1,308 persons from China who were shown by the NORC to have received doctorates from U.S. universities in 1996. The Social Security Administration found that 5 of these 1,308 had Social Security numbers that were invalid and 29 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 1,274 with presumed valid Social Security numbers. The Social Security Administration reported that 1,199 of the 1,274 individuals were recorded as having earned \$5,000 or more in 2001. This can be used to calculate a stay rate of 1,199/1,274 or 93.4 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 2.2 percent of foreign citizens had birth years that did not match within one year. A failure to match birth years in 2.2 percent of cases is not surprising since neither organization has 100 percent accuracy recording birth year. Further it's possible that some people report a different birth year to each organization. A previous study by the author (Finn, 2001) examined similar data for U.S. citizens. It found that among U.S. citizen doctorate recipients from recent graduating classes 2.1 percent had birth years that did not match when comparing records from the Social Security Administration and the *Survey of Earned Doctorates* in a fashion that was identical to the one used here. Since this is almost identical to the 2.2 percent rate of non-matches found here for foreign citizens it can be concluded that there is no more than a trivial difference between

foreign and U.S. citizen doctorate recipients in this regard. We exclude cases with birth years failing to match and thus assume that their stay rates are the same as others with similar characteristics whose birth years do match. Because foreign doctorate recipients are nearly identical to U.S. doctorate recipients in this regard, and because the number where there is not a birth year match is only 2.1 percent of the total, this does not seem like a significant source of bias in the stay rate estimates produced in this report.

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 1993 to 2001. This produced only one group 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. Permanent residents receiving doctorates in 1999 in mathematics were combined with permanent residents receiving computer science doctorates to comply with the confidentiality rules. This is why Table 1 in the text of this report combines mathematics and computer science, while Table 5, which includes only temporary residents, is able to show the two fields separately.

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 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 (SSN), 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 the SSN's recorded for a few graduates were never issued by the Social Security Administration. Table A-1 shows how the proportion missing valid SSN's varies by year of graduation and degree field.

Table A-1 shows that the highest percentages missing valid SSN's were observed among temporary residents with degrees in "other social science", and computer science. The percentage missing valid SSN's was consistently below average in life sciences. Detailed data not shown here also indicate that doctorate recipients from the countries with above average stay rates tend also to have valid SSN's more often average.

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

	1996 Temporary Residents	1999 Temporary Residents	1996 Permanent Residents	1999 Permanent Residents
Total, All S/E	6.8	5.9	3.2	4.8
Physical science	6.4	6.2	2.2	4.4
Mathematics	6.0	6.0	1.9	3.8
Computer science	7.1	8.5	6.5	3.8
Agricultural science	5.5	7.7	5.9	3.9
Life science	5.1	5.0	2.5	3.9
Computer/EE engineering	7.6	5.1	3.3	6.7
Other engineering	6.9	5.8	3.1	6.8
Economics	7.5	7.9	5.1	6.3
Other social science	11.9	6.7	5.3	3.6

Source: Oak Ridge Associated Universities.

A low-case assumption could be made that all persons with missing or invalid SSN's 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 could be that the persons with missing or invalid SSN's 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). However, this is implausible as those planning to leave the United States after graduation have less need for a SSN. A middle ground between these two extremes was chosen. The estimates reported in the body of this report are always the average of the high and low cases, described above. Thus, in the estimates, the stay rate for those with missing numbers is half the stay rate for those with valid SSN's in the same group. Making this adjustment had the result of reducing the stay rate by 1.4 percentage points for the 1999 cohort and by 1.9 percentage points for the 1996 cohort. This adjustment 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. A further reason why this middle ground assumption seems reasonable is that there are U.S. citizens in the same data files and some of these have the same problem. In a previous report by the author 3.9 percent of U.S. citizen doctorate recipients were found to have missing SSN's or failure to match birth years. (Finn, 2001)

Some detailed estimates would be affected more or less than the average. The estimate with the greatest proportion of missing or invalid SSN's is that for doctorate recipients from Canada. The estimated stay rate for Canadians in Table 5 would be 4.1 percentage points higher if no adjustment had been made for missing and invalid numbers. This is an extreme case. The adjustment for Iran was 3.0 percentage points. All others were adjusted by less than 3 percentage points.

After adjustment for missing SSN's, the proportion paying taxes on at least \$5,000 in earnings covered could be interpreted as a stay rate. This would be valid if we could assume that all doctorate recipients staying in the country pay 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 percent. 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.² 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 2000 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, 1999 doctorate recipients who were in the United States in 2001 were used to estimate the proportion of temporary residents who were here two years after graduation but who earned less than \$5,000 in 2001. To improve sample size this group was defined to include graduates from 1998 and 2000 as well so that the average date of graduation was 1999. To further reduce the effect of sampling error similar estimates were made using the 1993 and 1997 surveys and then the estimates for these three surveys were averaged. The resulting estimate was that 3.3 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 1999 temporary resident doctorate recipients were adjusted upward on the assumption that, like those in earlier years, about 3.3 percent would not have earnings of \$5,000 even though they resided in the United States. Similar sets of estimates were constructed for the 1996 graduates residing in the United States in 2001: 2.9 percent of them are estimated to have had earnings below the threshold. Similar sets of estimates were constructed for the 1991 graduates residing in the United States in 2001: 3.0 percent of them are estimated to have had earnings below the threshold.

Effect of the Adjustments

The adjustments for missing and invalid SSN's 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 1999 doctorate recipients in 2001. This increased from 71.2 percent to 71.4 percent (rounded to 71 percent in Table 1) because of the net effect of adjustments. Table 3 shows a stay rate estimate for 1996 doctorate recipients in 2001. This increased from 64.9 percent to 65.47 percent (rounded to 65 percent in Table 3) because of the net effect of adjustments. Table 4 shows a stay rate for 1991 doctorate recipients of 58 percent in 2001. This increased from 57.6 percent to 58.4 (rounded to 58 percent in Table 4) percent as a result of the adjustments. The effect of adjustments was only somewhat greater for sub-categories such as degree field groupings. The effect of adjustments changed the degree field specific stay rates by less than 2 percentage points in all cases. The effect of adjustments was greatest for the country specific stay rates in Table 7. The stay rates for two of the countries changed as a result of adjustments by more than two percentage points. The stay rate for Canada would have been 2.2 percent higher if unadjusted rates were used, and for China it would have been 2.6 percent lower. Canada has a relatively high proportion of doctorate recipients without valid SSN's in the database, and China has a relatively low proportion without valid SSN's. In one case the adjustment for missing social security numbers was more than enough to offset the effect of the two other adjustments; in the other case it was not nearly enough. As these were the largest changes for any of the sub-groups adjusted in the manner described, it should be clear that the impact of these adjustments was small, even for sub-groupings of doctorate recipients.

²These were published in National Research Council, 1989, p.114.

There is an estimate on page 6 of this paper which addresses the issue of 1991 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 2001 stay rate (58 percent) “would be 23.5 percent higher if the rate were to represent the proportion who had worked in the United States for at least one year during the 1992 to 2001 period.” 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 an unadjusted estimate seems justified.

Sampling Error

The *Survey of Earned Doctorates* is not a sample survey. Sampling was not employed to identify groups of Social Security numbers from the *Survey of Earned Doctorates* database. Each estimate for a stay rate in this report used the Social Security numbers of all doctorate recipients with valid Social Security numbers reported to the *Survey of Earned Doctorates*. Thus, there is no sampling error in the unadjusted stay rate estimates. However, one of the adjustments made involved estimating the proportion of recent doctorate recipients in the United States who did not have any earnings in 2001 or who had earnings less than \$5,000. These estimates were made using the *Survey of Doctorate Recipients* which is a sample survey. We tried to reduce the role of sampling error by combining estimates from three survey years to make adjustments. However, because the estimated proportions are small and the underlying populations are relatively small, sampling error is likely to be fairly large relative to the estimates of the proportion earning less than \$5,000. In spite of this, there is little need to report sampling errors for these estimates because, as was demonstrated above, the adjustments had very small net impacts. In fact, the net impact of the three adjustments was such that it made no difference in the stay rate estimates for all S/Es, once these were rounded to the nearest percent.

REFERENCES

Finn, Michael G. Stay Rates of Foreign Doctorate Recipients from U.S. Universities, 1999, Oak Ridge, TN: Oak Ridge Institute for Science and Education, 2001

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

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

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

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

National Science Foundation, Science and Engineering Doctorate Awards – 1996, Arlington, VA (NSF 97-329-314).

National Science Foundation, Science and Engineering Doctorate Awards – 2000, Arlington, VA (NSF 02-305).