

# **Stay Rates of Foreign Doctorate Recipients from U.S. Universities, 1997**

Prepared by:

Michael G. Finn  
Analysis and Evaluation Programs  
Science and Engineering Education  
Oak Ridge Institute for Science and Education

August 2000

This document describes activities performed under a contract between the U.S. Department of Energy and Oak Ridge Associated Universities. Research for this document was supported by a grant from the Division of Science Resources of the National Science Foundation to Oak Ridge Institute for Science and Education.

All opinions expressed in this document are the author's and do not necessarily reflect policies and views of the U.S. Department of Energy, the Oak Ridge Institute for Science and Education, or the National Science Foundation.

## Highlights

This study estimated the proportion of foreign recipients of science and engineering (S/E) doctorates from U.S. universities who stayed in the United States after graduation. The primary data used to estimate stay rates were special data tabulations obtained from the Social Security Administration on the proportion of persons in various groups that paid social security taxes.

- More than half (53 percent) of the temporary resident S/E doctorate recipients from U.S. universities in 1992-1993 were in the United States in 1997.
- The 53 percent overall stay rate for 1992-1993 doctorates varies by discipline from 32 percent for social sciences/psychology to 62 percent for the physical sciences. Life sciences and engineering stay rates were 54 percent. Within life sciences, the stay rate ranges from agriculture with 30 percent temporary residents staying in the United States; to biochemistry and the other biological sciences where the stay rate was over 60 percent.
- Stay rates vary dramatically by country of citizenship at the time of the S/E doctorate award. China and India have the highest stay rates; Korea and Brazil the lowest. The variation is so great that doctorate recipients from China are staying in the United States at 10 times the rate of those from Korea.
- There was a substantial increase in the stay rate of foreign doctorate recipients from U.S. universities in the decade leading up to the 1997 estimates reported here. There was also a substantial increase in doctorate degrees awarded to non-U.S. citizens prior to the mid-1990s. With both the number of degrees and the stay rate increasing, this led to very dramatic increases in the number of foreign doctorate students staying to join the U.S. workforce in the early 1990s.
- Stay rates of a given cohort are quite stable over time. Temporary residents receiving S/E doctorates in 1987 had a stay rate of 45 percent after 5 years, declining only to 44 percent after 10 years. However, this stability in the total rate masks some movement back and forth between foreign nations and the United States. About 8 percent of those from the 1987 cohort who were here after 10 years were not in the United States after 5 years.
- An increasing number of foreign students are permanent residents by the time they receive a doctorate in an S/E field. The stay rate for permanent resident doctorate recipients from U.S. universities in 1992-1993 was 78 percent in 1997. As with temporary residents, the stay rate for those with social science doctorates is below this average, and the rate for engineering and physical sciences is somewhat higher.
- Most permanent resident doctorate recipients came to the United States after earning a bachelor's degree elsewhere. Although those with foreign bachelor's degrees had been here for a shorter period of time, they stayed in the United States after graduation at rates that were almost the same as other permanent residents with bachelor's degrees from U.S. universities.

## 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.<sup>1</sup> The stay rate is always specific to a particular year, e.g., 1997. Each line in the several tables that follow describes a different group of these degree recipients.

## Stay Rates of Temporary Residents

Table 1 provides stay rates for 1992 and 1993 foreign doctorate recipients in 1997 and in earlier years. This table contains information only on persons with a temporary visa at the time of graduation. Sampling error can have little impact because the overall sampling rate for the estimates in Table 1 was 52 percent.<sup>2</sup>

**Table 1. Temporary Residents Receiving S/E Doctorates from U.S. Universities in 1992-1993 Who Were in the United States, 1994 to 1997**

	Temporary Resident Doctorate Recipients	Percent in the United States			
		1994	1995	1996	1997
Total, All S/E	15,861	48	51	53	53
Physical sciences	4,729	56	60	61	62
Life sciences	3,765	48	49	53	54
Social sciences	2,168	29	31	32	32
Engineering	5,199	50	53	53	54

Source: Oak Ridge Associated Universities.

Table 1 shows that stay rates are almost stable during the period from 2.5 to 4 .5 years since graduation. The slight increase in stay rates that occurs during from 1994 to 1997 may be mostly a statistical artifact. It appears that some persons on postdoctoral appointments do not pay social security taxes on their earnings, although this is thought to be small and confined to estimates for the first years after graduation when postdoctoral appointments are common. Another reason why stay rates in the first years after graduation are smaller is that some students study on a visa that requires them to leave the United States for at least two years after graduation. Thus, stay rate estimates for 1997 are probably the most useful for giving an indication of the proportion of foreign doctoral students who stay in the United States after graduation.

The estimates in Table 1 can be directly compared with estimates made for cohorts who graduated in 1987-1988.<sup>3</sup> (Table 2.) There are no significant differences in the methods or data sources used to estimate Tables 1 and 2. However, Table 1 shows a 53 percent

stay rate for the last year as compared with only 41 percent in Table 2. This is a significant increase in stay rates over the five-year period.

**Table 2. Temporary Residents Receiving S/E Doctorates from U.S. Universities in 1987-1988 Who Were in the United States, 1989 to 1992**

	Temporary Resident Doctorate Recipients	Percent in the United States			
		1989	1990	1991	1992
Total, All S/E	8,570	36	40	41	41
Physical sciences	2,585	38	45	45	46
Life sciences	1,543	22	27	30	32
Social sciences	1,440	28	30	30	30
Engineering	3,002	44	47	48	48

Source: Michael G. Finn, Leigh Ann Pennington, and Kathryn Hart Anderson, 1995, pp. 6-7.

The number of degrees awarded to foreign students also increased dramatically in recent years. The combination of the two meant a very large increase in the number of foreign doctorates entering the work force during the 1990s.

Table 3 documents this increase. It compares the 1987-1988 cohorts with the 1992-1993 cohorts. The increase in degree awards during this five-year period was large in each of the discipline groups examined, ranging from a “low” of 57 percent in the social sciences to 98 percent in the life sciences.

The right side of Table 3 estimates the number of foreign graduates on temporary visas who were still in the United States four to five years after graduation. The increase in stay rates (discussed above) and the increase in degrees awarded to foreigners on temporary visas are each smaller than the effect of the two combined. This is shown in the last column of Table 3, which simply summarizes the difference in the two preceding columns. Since nearly all recent doctorates are in the labor force, this last column can be thought of as describing the increase in the supply of labor made up of foreigners on temporary visas at the time of graduation, which by any standard are very dramatic increases. To put this in perspective, doctorates awarded to U.S. citizens and permanent residents in these fields increased by only 6.5 percent during the same five-year period.<sup>4</sup>

**Table 3. S/E Doctorates Awarded to Temporary Residents and Changes in the Number Staying in the United States, Classes of 1987-1988 and 1992-1993**

	Doctorates to Temporary Residents		Percentage Increase in Doctorates from 1987-1988 to 1992-1993	Doctorates to Temporary Residents Who Stayed in the U.S. for 4 to 5 Years		Percentage Increase in Doctorates Awarded to Stayers
	1987-1988	1992-1993		1987-1988	1992-1993	
Physical sciences	2,851	4,821	69	1,314	3,030	131
Life sciences	1,683	3,324	98	547	1,810	231
Social sciences	1,617	2,532	57	479	801	67
Engineering	3,253	5,525	70	1,545	2,989	93

Source: NSF, Science and Engineering Doctorate Awards: 1997, and Oak Ridge Associated Universities.

While the above discussion documents that there was a sharp increase in both the stay rate and the number of foreign doctorate recipients on temporary visas for the period examined, an obvious question is whether these trends have continued in more recent years.

The rapid increase in degrees awarded to foreign students abated after 1993. In 1994, there was a drop in degrees awarded to persons on temporary visas and an increase in degrees to persons on permanent visas, which was primarily due to the Chinese Student Protection Act. This law granted permanent resident status to thousands of Chinese students and their families in 1993 and 1994. Clearly the decline in temporary resident degree awards after 1993 is an artifact of this law. From 1993 to 1995, awards to Chinese students on temporary visas fell from 1,875 to 583, and awards to Chinese students on permanent visas rose from 352 to 2,169.<sup>5</sup> Thus, it is appropriate to look at trends in total doctorate awards to non-U.S. citizens when asking whether the growth continued after 1993.

Table 4 shows total degree awards and awards to non-U.S. citizens. The increase in awards to non-U.S. citizens slowed down after 1993 and ended in 1996. The rather large decline shown for 1997 is probably a statistical artifact. In that year there were changes in survey procedures and the number of doctorate recipients with citizenship classified as “unknown” increased sharply. Future revisions to this data series are expected and will probably show that there was little or no decline in awards to foreign nationals in 1997 or 1998. However, it is clear that the very strong growth experienced from the mid-1980s to 1994 has abated.

**Table 4. S/E Doctorates Awarded by U.S. Universities, by Citizenship, 1988 to 1998**

Citizenship	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Total, S/E	21,328	21,732	22,868	24,023	24,675	25,443	26,205	26,535	27,229	27,180	27,272
Total Non-U.S.	6,066	6,515	7,768	8,926	9,475	9,754	10,542	10,503	10,809	9,240	9,159
Temporary Visas	4,936	5,391	6,571	7,641	8,092	8,113	7,521	6,994	7,802	6,963	7,143
Permanent Visas	1,130	1,124	1,197	1,285	1,383	1,641	3,021	3,509	3,007	2,277	2,016
Total U.S.	13,368	13,468	14,167	14,629	14,559	14,932	15,166	15,487	15,621	15,973	16,109
Unknown	1,894	1,749	933	468	641	757	497	545	799	1,967	2,004

Source: NSF, Science and Engineering Doctorate Awards: 1998.

Stay rates for non-U.S. citizens receiving degrees in 1997 are shown in the last column of Table 5 and are compared with similar graduates from earlier years. These stay rates are recorded only two years after graduation. Stay rates observed so early after graduation have tended to be somewhat lower than stay rates observed for the same classes 4 or more years after graduation. Nevertheless, the estimated stay rates in Table 5 are instructive because they show that stay rates for temporary residents have not continued to increase but may have peaked around 1995, i.e., with the class of 1993.

**Table 5. Temporary Residents Receiving S/E Doctorates from U.S. Universities Who Were in the United States Two Years After Graduation, 1986 to 1997**

	Percent in the United States, by Year of Doctorate				
	1986	1989	1992	1995	1997
Total, S/E Fields	40	36	45	51	47
Physical sciences	46	38	52	59	52
Life sciences	24	22	38	57	43
Social Sciences	26	28	27	26	27
Engineering	52	44	52	51	57

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.

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

While Table 5 suggests that stay rates for non-U.S. citizens on temporary visas peaked in the mid-1990s, there is an important qualification. As noted already, the class of 1995 contained a sharply lower number of students from China on temporary visas because many more from China were granted permanent visas while in graduate school. Thus, starting in 1997, one really needs to look at the total stay rate for non-U.S. citizens (including both temporary and permanent residents). These estimates are not available for recipients as recent as 1995. However, the stay rate for permanent residents is very high. Because the number of doctorates awarded to permanent residents increased sharply for the years 1993-1996 (Table 4), the modest decline for temporary residents

shown in Table 5 probably does not signal a decline in the stay rate for all non-U.S. citizen doctorate recipients.

Table 6 contains the same data shown in Table 1 disaggregated by country of citizenship at time of doctorate award. Stay rates differ sharply by country of origin. Consider the four largest source countries: Taiwan, Korea, China, and India. China has the highest stay rate, followed by India which is lower but still above the average for all countries. Taiwan is below average, and Korea is far below average. The variation is so great that doctorate recipients from China are staying in the United States at 10 times the rate of those from Korea.

Among other individual countries in Table 6, a large number of foreign students come from Korea, but their stay rates are among the lowest. India remains a big source of foreign students even though its relative position has declined. The stay rate for Indian students is second only to China in each of the four discipline groups examined. The stay rate for students from Taiwan is substantially below average in every discipline group. Non-Asian countries tend to account for relatively few of the foreign doctorate recipients, but there are some interesting observations to be made nevertheless. Students from the United Kingdom stay in the United States after graduation at above-average rates overall, but not in all degree fields. Brazil has a stay rate that is well below average, and so does Mexico, although to a lesser extent.

This is the first time the author has estimated stay rates for France, Israel, South Africa, or Australia/New Zealand. Table 6 indicates that the doctorate recipients from each of these countries stayed at rates lower than the total for all countries. In the case of Australia/New Zealand and France, the stay rate was about half that of all countries combined.

**Table 6. Temporary Residents Receiving S/E Doctorates From U.S. Universities in 1992-1993 Who Were in the United States, 1994 to 1997**

Country of Origin and Degree Field	Temporary Resident Doctorate Recipients	Percent in the United States			
		1994	1995	1996	1997
Total, Physical Sciences	4,821	55	59	60	61
Taiwan	489	35	36	36	36
Korea	437	12	11	9	9
Japan	48	14	19	22	22
China (PRC)	1,698	82	89	90	94
India	423	72	77	80	81
Iran	46	54	60	67	67
Australia/New Zealand	34	30	34	41	37
Egypt	20	34	31	34	34
Israel	49	36	37	41	43
South Africa	22	45	50	55	50
United Kingdom	67	48	55	59	59
France	57	14	11	15	17
Germany	94	33	41	41	36
Greece	98	38	44	46	48
Brazil	56	19	15	15	15
Mexico	49	34	34	29	32
Canada	137	35	44	48	50
All other	997	41	46	46	43
Total, Life Sciences	3,765	48	51	53	54
Taiwan	421	36	38	40	41
Korea	350	25	21	18	17
Japan	45	29	34	37	44
China (PRC)	1,074	82	85	88	92
India	237	70	75	82	79
Iran	44	54	51	51	47
Australia/New Zealand	25	11	13	17	20
Egypt	54	27	29	31	35
Israel	16	22	29	27	25
South Africa	17	27	27	27	27
United Kingdom	44	28	31	31	50
France	23	25	35	32	28
Germany	39	27	39	30	32
Greece	30	53	42	46	53
Brazil	86	7	9	12	13
Mexico	85	18	19	22	22
Canada	123	40	41	45	45
All other	1,052	29	32	35	35
Total, Social Sciences	2,278	29	31	32	32
Taiwan	163	14	12	12	12
Korea	416	6	5	6	5
Japan	78	9	8	8	5
China (PRC)	255	62	67	67	70
India	149	56	56	58	58
Iran	20	39	40	40	41
Australia/New Zealand	32	11	13	17	20
Egypt	18	18	18	24	18
Israel	37	22	29	27	25
South Africa	20	24	30	31	31
United Kingdom	50	42	42	43	43



**Table 6. (Continued)**

Country of Origin and Degree Field	Temporary Resident Doctorate Recipients	Percent in the United States			
		1994	1995	1996	1997
France	15	25	35	32	28
Germany	38	19	25	32	29
Greece	35	47	35	32	36
Brazil	35	10	14	14	14
Mexico	41	18	19	22	22
Canada	124	38	41	40	41
All other	752	27	29	31	30
<b>Total, Engineering</b>	<b>5,527</b>	<b>50</b>	<b>53</b>	<b>53</b>	<b>54</b>
Taiwan	1,076	33	36	37	37
Korea	853	11	10	7	8
Japan	43	24	27	27	27
China (PRC)	983	89	94	96	97
India	740	85	89	89	90
Iran	118	52	55	56	55
Australia/New Zealand	13	30	34	41	37
Egypt	88	34	31	34	34
Israel	38	36	37	41	43
South Africa	11	45	50	55	50
United Kingdom	23	86	92	86	87
France	50	28	35	39	42
Germany	33	37	56	55	59
Greece	117	40	43	46	46
Brazil	74	21	19	21	17
Mexico	38	40	34	31	34
Canada	71	56	61	57	61
All other	1,158	45	48	50	50
<b>Total, All S/E Fields</b>	<b>16,391</b>	<b>48</b>	<b>51</b>	<b>52</b>	<b>53</b>
Taiwan	2,149	33	34	36	36
Korea	2,056	13	11	9	9
Japan	214	17	20	21	21
China (PRC)	4,010	82	88	90	92
India	1,549	77	80	82	83
Iran	228	52	54	56	55
Australia/New Zealand	104	19	22	28	28
Egypt	180	30	29	32	33
Israel	140	31	34	36	36
South Africa	70	35	39	41	39
United Kingdom	184	46	50	51	56
France	145	22	26	28	28
Germany	204	30	40	39	38
Greece	280	42	42	44	46
Brazil	251	14	14	15	15
Mexico	213	25	25	25	27
Canada	455	40	45	47	48
All other	3,959	36	39	41	40

Notes: "s" denotes suppressed for reasons of confidentiality.

Physical sciences include geological sciences, mathematics, and computer sciences.

Social sciences include psychology.

Australia and New Zealand, Egypt, Israel, and South Africa are shown with separate estimates for each of the four major discipline groups. However, to preserve confidentiality for each of these countries when estimating the percentages shown above, physical sciences was combined with engineering; and life sciences was combined with social sciences.

Source: Oak Ridge Associated Universities.

Table 7 indicates that the patterns of stay rate differences by country of citizenship have changed little from 1992 to 1997. In each of these years, China and India had the highest stay rates while Japan, Brazil, and South Korea had the lowest stay rates. Among the Asian countries that supply most of the foreign doctorate recipients, the stay rates for China and India have increased while the rates for Taiwan and Korea have declined.

Table 7 indicates that the patterns of stay rate differences by country of citizenship have changed little from 1992 to 1997. In each of these years, China and India had the highest stay rates while Japan, Brazil, and South Korea had the lowest stay rates. Among the Asian countries that supply most of the foreign doctorate recipients, the stay rates for China and India have increased while the rates for Taiwan and Korea have declined.

**Table 7. Stay Rates for Selected Countries, 1992, 1995, and 1997**

	1987-1988 Doctorate Recipients in 1992	1990-1991 Doctorate Recipients in 1995	1992-1993 Doctorate Recipients in 1997
Total, All Countries	41	47	53
China	65	88	92
India	72	79	83
United Kingdom	na	59	56
Canada	32	46	48
Greece	44	41	46
Germany	na	35	38
Taiwan	47	42	36
Japan	17	13	21
Brazil	13	25	15
Korea	17	11	9

Note: Total includes countries not shown separately.

Source: Oak Ridge Associated Universities.

The stay rates reported in Table 6 aggregate science and engineering disciplines into 4 broad groups. Table 8, however, provides more detail within the physical sciences and life sciences. Within the life sciences group, nearly one-fourth of Ph.D.s were awarded in the agricultural sciences. Agricultural sciences has a stay rate of only 30 percent, less than half the rate of the other life sciences. Clearly, it would be misplaced to aggregate these two for purposes of estimating stay rate.

**Table 8. Temporary Residents Receiving S/E Doctorates From U.S. Universities in 1992 or 1993 Who Were in the United States, by Detailed Degree Field, 1994 to 1997**

	Temporary Resident Doctorate Recipients	Percent in the United States			
		1994	1995	1996	1997
Total, Life Sciences	3,765	48	49	53	54
Biochemistry	435	53	56	64	67
Agricultural sciences	920	27	30	30	30
Other life sciences	2,410	55	56	61	61
Total, Physical Sciences	4,729	56	60	61	62
Chemistry	1,404	59	65	65	66
Physics/astronomy	1,193	59	65	67	69
Mathematics	1,028	50	52	53	52
Computer science	713	56	59	62	62
Other physical sciences	391	48	51	53	52

Source: Oak Ridge Associated Universities.

The 1997 rates are the best estimates. We see that the physical sciences group is more homogeneous. Mathematics and other physical sciences show stay rates of 52 percent, significantly lower than chemistry, physics, or computer science. The physics students' stay rate of 69 percent was the highest. Note that the fields where postdoctoral appointments are most common (e.g., biochemistry, chemistry, and physics) show the largest increases in stay rates from 1994 to 1997. This is consistent with the observation that there is probably some underestimate of stay rates during the first years following graduation<sup>6</sup> because some employers of postdocs do not withhold social security taxes.

### **The 1987 Cohort in 1992 and 1997**

An analysis conducted of 1987 graduates estimated a ten-year stay rate and the extent to which doctorate recipients leave and reenter the United States over a ten-year period. Table 9 indicates that the stay rate for all temporary residents who received S/E doctorates in 1987 was 45 percent in 1992 and fell to only 44 percent in 1997.

It is not surprising that the stay rates in Table 9 are not as high as rates shown earlier in this paper for more recent cohorts. We already knew that four-year stay rates had increased in recent years.

Estimated stay rates for the years between 1992 and 1997 are also shown. Taken together, these rates indicate that the stay rate for the class of 1987 was very stable; i.e., it did not fluctuate to any significant extent between 1992 and 1997. However, this does not mean that the doctorates who were here 10 years after graduation had been here all along. It is possible that there is a constant movement back and forth between foreign

nations and the United States. We know that some foreign doctorate recipients leave the United States after acquiring several years of work experience here. If the overall rates are stable, there could be two different explanations. First, it may be that the number returning between year 5 and year 10 postgraduation is really very small. Second, there must be a flow in both directions. If the movement out were balanced by an equal movement back (of persons who had left earlier), this could explain the stability of the estimates in Table 9.

**Table 9. Temporary Residents Receiving S/E Doctorates from U.S. Universities in 1987 Who Were in the United States in 1992 and 1997**

	Temporary Resident Doctorate Recipients	Percent in the United States				
		1992	1994	1995	1996	1997
Total, All S/E	4,032	45	45	44	44	44
Physical sciences	923	55	54	53	52	52
Life sciences	877	36	39	40	40	39
Social sciences	700	31	32	30	30	29
Engineering	1,532	51	48	48	48	48

Source: Oak Ridge Associated Universities.

Table 10 shows one aspect of the two-way flows by estimating the proportion of those here in 1997 who were not here in 1992. The table shows that 8 percent of the temporary residents who were here 10 years after completing their doctorate programs in 1987 were not here at the five-year point, 1992. Alternatively, we could state that no more than 92 percent of those who were here after 10 years had been here continuously throughout the ten-year period.

**Table 10. Temporary Residents Receiving S/E Doctorates From U.S. Universities in 1987 Who Were in the United States in 1997 But Not in 1992**

	Temporary Resident Doctorate Recipients	Percent
Total, All S/E	4,032	8
Physical sciences	923	6
Life sciences	877	14
Social sciences	700	4
Engineering	1,532	7

Source: Oak Ridge Associated Universities.

Table 10 can be used in conjunction with Table 9. For example, from Table 9 we know that 44 percent of the 4,032 temporary residents receiving S/E doctorates in 1987 were still in the United States in 1997. Table 10 indicates that 8 percent of the 43 percent were not here in 1992. Thus, we know that at least 3.5 percent of the 1987 graduates left the United States and then returned by 1997. Actually, the total of those that left and returned by 1997 is probably considerably higher than 3.5 percent since a person who both left and returned prior to or after 1995 would not be included in this 3.5 percent estimate. It seems plausible that the total of 1987 graduates who went abroad for at least a year but returned to work in the United States in 1997 is several times 3.5 percent; however, data to estimate this more precisely is not available.

As Table 10 indicates, the proportion of those here 10 years after graduation but not 5 years after graduation varies considerably by degree field. The movement of these scientists between countries seems to be most pronounced in the life sciences where 14 percent of those here in 1997 were not here in 1995.

### **Stay Rates of Permanent Residents**

Many discussions of foreign students refer to only those on temporary visas, but a discussion of stay rates for foreign nationals with permanent visas at graduation is useful as well. Students on permanent visas range from those who immigrated to the United States at a young age and have lived here ever since to those who came as graduate students and became permanent residents while completing their program of studies. One thing that this diverse group has in common is that they all have the right to stay and work in the United States. In employers' eyes, they are more attractive than foreign nationals without permanent resident visas because they require no change of visa to work and there is virtually no risk that they would be forced to leave the United States after a few years because of visa problems. The stay rates of these permanent residents are shown in Table 11.

The overall stay rate for doctorate recipients from the 1992-1993 classes was 78 percent in 1997. The stay rate for U.S. citizens is not 100 percent but is probably more than 95 percent. Thus, a 78-percent stay rate for doctorate recipients on permanent resident visas indicates their stay is about halfway between the stay rate for temporary residents, 53 percent as shown in Table 1, and the rate for U.S. citizens. It should be noted, however, that the nearly one-fourth of these permanent residents who were outside the United States in 1997 include some who obtained employment in the United States but were assigned to work outside the United States by their employer.

Stay rates in Table 11 are lowest for social science degree recipients and highest for engineering. These observed degree field differences may be due in part to underlying country of origin differences. Students from China and India have very high stay rates, but Chinese and Indian students as a percentage of the total are higher in the physical and life sciences and lower in the social sciences and psychology.

**Table 11. Percentage of Permanent Residents Receiving S/E Doctorates From U.S. Universities in 1992-1993 Who Were in the United States, by Degree Field, 1994 to 1997**

Degree Field	Permanent Resident Doctorate Recipients	Percent in the United States			
		1994	1995	1996	1997
Total, All S/E	3,074	75	76	77	78
Physical sciences	811	78	79	78	80
Life sciences	760	69	70	74	77
Social sciences	623	70	70	70	67
Engineering	880	82	83	84	84

Source: Oak Ridge Associated Universities.

It is a reasonable conjecture that length of time in the United States would be positively related to stay rates for this group of permanent residents. Those who came to the United States for undergraduate study or immigrated earlier with their parents are likely to have fewer ties to foreign lands and at the same time to be more completely socialized into American culture. As a group, they probably have greater proficiency with English and perhaps less proficiency with their native language. This suggests that the group of permanent residents shown in aggregate in Table 11 may include two rather different types with different stay rates.

Table 12 presents stay rates separately for two subgroups of doctorate recipients: those who earned a bachelor's from a U.S. college or university prior to entering graduate school, and those who did not. Two facts stand out. First, only 670 earned bachelor's degrees in the United States, far fewer than the 2,404 who did not. Second, while those who earned bachelor's degrees in the United States had an overall higher stay rate, 80 versus 77 percent, this difference is so small as to be trivial. The fact that the stay rate is nearly as high for those with foreign bachelor's degrees as for those who attended colleges in the United States was unexpected. Clearly, while stay rates are much higher for foreign nationals with permanent resident status at graduation as compared with those temporary residents, there is no substantial variance in stay rates related to time in the United States within the group of permanent residents.

**Table 12. Permanent Residents Receiving S/E Doctorates in 1992-1993 Who Were in the United States, by Location of Bachelor's Institution and Degree Field, 1994 to 1997**

Degree Field	Permanent Resident Doctorate Recipients	Percent in the United States			
		1994	1995	1996	1997
Total, Bachelor's Earned in U.S.	670	80	81	80	80
Physical sciences	140	86	85	79	78
Life sciences	152	72	79	80	81
Social sciences	178	77	76	74	75
Engineering	200	83	85	85	86
Total, Bachelor's <u>Not</u> Earned in U.S.	2,404	74	75	76	77
Physical sciences	671	76	77	77	80
Life sciences	608	69	68	73	76
Social sciences	45	67	68	68	64
Engineering	80	82	83	84	83

Source: Oak Ridge Associated Universities.

Interestingly, though we do not know why some permanent residents move abroad upon graduation, we can safely predict higher rates for permanent residents the next time this study is updated two years from now. This is because there was a substantial increase in doctorates awarded to Chinese students with permanent resident status as a result of the Chinese Student Protection Act. The Chinese students on temporary visas are staying at rates well above those for all permanent residents, and the Chinese on permanent visas can be expected to do the same.

## TECHNICAL APPENDIX

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

### Sources of Data

Data for the report consist almost exclusively of a set of more than 116 groups of Ph.D. recipients who received S&E degrees from U.S. universities in 1987, 1992-1993, and 1995. This project was discussed carefully with staff of the National Opinion Research Center (NORC), the National Science Foundation, 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.

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 postgraduation plans. Answers to these questions were used to define and identify groups for which stay rates were estimated (e.g., temporary residents graduating in 1992-1993 with a degree in engineering). 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 of 300 was used in cases where the total in the group was greater than 300 persons. In total, groups of foreign citizens containing a total of 19,626 persons were identified. In addition, 18 groups of U.S. citizens containing a total of 4,866 persons were identified. These were used to help make adjustments to raw data received from the Social Security Administration.

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 2.0 percent of U.S. citizens and 2.3 percent of foreign citizens had birth years that did not match within one year. This is not surprising since neither organization has 100 percent accuracy recording birth year. As far as the difference between the United States and foreign citizens in this regard, 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 or don't want to



get Social Security numbers. Insofar as the second reason holds, the difference between the U.S. rate of false matches (2.0 percent) and the foreign rate (2.3 percent) could be used as an indication of false matches that made it through the screen. That is, 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., 1907 to 1997) that describe nearly all persons in the Social Security system in 1997, 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 1997. This produced several 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. The decision to use a threshold no higher than \$5,000 was based on the following reasoning. 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.

### **Adjustment to Data: Missing or Invalid Social Security Numbers**

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 does since they are used by both banks and universities for identification numbers. It is possible for students to go through graduate school without Social Security numbers, however, since most universities will issue a similar 9-digit ID number to foreign students who don't want to get U.S. Social Security numbers. These usually 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 3.1 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 social sciences graduates, and the second highest among life sciences graduates. Detailed data not shown here also indicate that the countries with above- average proportions missing valid Social Security numbers are nearly always countries with below-average stay rates. 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**

	1992-1993 Temporary Residents	1995 Temporary Residents	1992-1993 Permanent Residents
Total, All S/E	6.4	5.4	3.7
Physical sciences	4.1	4.7	2.5
Life sciences	7.5	6.3	5.4
Social sciences	12.2	8.1	5.5
Engineering	4.4	4.4	2.6

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. It turns out that the mid-case is not very different from the more extreme low case as the groups with relatively high proportions of missing Social Security numbers (e.g., graduates from Japan, Brazil, and Mexico) are almost always groups for which the holders of valid Social Security numbers recorded a stay rate of less than 30 percent.

### **Other Adjustments**

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, even for a group of U.S. citizen doctorate recipients who reside in the United States, it is likely that the percentage paying Social Security taxes is less than 100. The principal reasons would be non-employment, part-time or part-year employment, or employment by one of the relatively small number of employers not included in the Social Security program. 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. After obtaining estimates of the percentage paying taxes on at least \$5,000 in earnings for comparison groups of U.S. citizens, this percentage was adjusted upward to the extent that the U.S. citizens were not paying taxes for one of the reasons mentioned above.

Death rates of U.S. citizens were estimated by using the age-specific death rates recorded by the TIAA insurance company.<sup>7</sup> About 96 percent of all jobs in the United States are covered by Social Security. One area where non-participation in Social Security is relatively common is state government employment, including employment at state universities. The Social Security Administration does not cite an exact figure but indicates that more than 25 percent of state government employees are covered. In some states with partial coverage the newer hires are thought to have a much higher participation rate than older state employees. State government employment in three states (Ohio, Massachusetts, and Alaska) is still completely exempt from Social Security taxes, including persons employed by state universities in those states.<sup>8</sup> The Survey of Doctorate Recipients (SDR) was used to estimate the proportion of recent Ph.D.s in the sciences and engineering employed at universities in those states. Department of Education data were used to estimate the proportion among those employed in education in these states who were employed in public universities as opposed to private.<sup>9</sup> SDR data for 1995 were used to estimate unemployment rates, the percent out of the labor force, and the percent employed part-time. It was assumed that at least 3 percent of U.S. citizens are working outside the United States (after examining the proportion who reported to the SDR that they had worked abroad for at least 6 months, and the proportion who reported that they were working abroad at the time of the 1995 SDR).

Assumptions were made based on the best data available for all these factors, providing a set of adjustment factors that would account for the U.S. citizens working in the United States or looking for work in the United States. These adjustment factors were then applied to the estimates of stay rates for foreign graduates as they too take employment in state government jobs not covered by Social Security, and they experience similar rates for death and unemployment or part-time employment. Doing this caused the rates to increase for 1990-1991 foreign national recipients of engineering degrees by factors of 1.12 in the mid-case. The adjustment factor for other disciplines in the mid-case were: 1.10 for physical sciences, 1.11 for life sciences, and 1.10 for social sciences. The adjustments for missing Social Security numbers lowered the unadjusted rates obtained from the Social Security Administration. The other adjustments (e.g., for persons not in the labor force, or employed in non-covered employment) raised the rates. The net effect was that most stay rates reported in the main body of this report are very close to the unadjusted rates obtained from the Social Security Administration for the proportion earning \$5,000 or more. For example, for the 1990-1991 graduates, we reported the following 1995 stay rates in Table 1: 54 percent in engineering (compared with an unadjusted rate of 49 percent); 62 percent in physical sciences (compared with 56 percent unadjusted); 54 percent in life sciences (compared with 51 percent unadjusted); and 32 percent in social sciences (compared with 31 percent unadjusted).

Some restrictions on making estimates for small groups of doctorate recipients were necessary to protect confidentiality of individual's tax records. The Social Security Administration will not provide estimates for any group if all of the group members have the same status (e.g., none earned at least \$5,000 in 1997) or even if all but one or two persons have the same status. All cases where this restriction prevented estimates from being produced were attempts to provide country-specific estimates by discipline group. The size of the groups was quite small, and the stay rates were almost always very low. The problem was resolved by combining two similar groups for a combined estimate, then reporting this estimate for each group. For example, Table 6 shows a 1997 stay rate of 34 percent for physical scientists from Egypt and the same 34 percent stay rate for engineers from Egypt. Other estimates that were constructed by combining two discipline groups for the same country of citizenship were: Israel, South Africa, and the country grouping of Australia/New Zealand. Also in Table 6, the social sciences were combined with the life sciences to produce estimates for Australia/New Zealand, Israel, France, and Mexico. There was one other situation where two groups were combined and the combined estimate was used for each. In the physical sciences grouping, France and Japan were combined. While it is undesirable to combine countries in this manner when the goal is to produce country-specific estimates, the damage would probably be slight as both countries had very low stay rates in the past. Table 6 reports a 1997 physical sciences stay rate of 14 percent for each of these countries. While it is not known that each is exactly 14 percent, the fact that the combined rate is so low means that the true stay rate for each of these two countries is well below the average for all countries.

In addition, some other minor adjustments should be noted. For a portion of the physical sciences group (the mathematics and computer science subset), there were too few

sample cases to get an estimate from the Social Security Administration for either Japan or France. These two were combined for the estimate of that portion – to the extent the estimated stay rate differs between these two countries in physical sciences it is due to the other disciplines in physical sciences. It was thought that this would distort the resulting estimates very little because for both France and Japan the stay rates were very low in the other disciplines included in this category (chemistry, physics, etc.). Also, the inability of the Social Security Administration to produce an estimate made it very likely that there were few French and few Japanese doctorate recipients in math or computer science who stayed.

For the physical sciences group, the group stay rate was calculated two different ways. One was to take the weighted average of the separately estimated stay rates for the five disciplines comprising this group. Another was to take the weighted average of the separately estimated stay rates for 15 different countries or country groups. In each case, the estimate was based on a large sample, but a sample nevertheless. For one the estimated rate for 1997 was 60.1 percent, for the other 61.9 percent. This difference could plausibly have been produced by sampling error. Rather than choose one of the two estimates as the best, the weighted average of the two was computed and used instead. Thus, Table 4 shows a stay rate in physical sciences in 1997 of 61 percent. For the life sciences group this was not necessary as the two approaches produced estimates, that were identical after rounding.

Table 10 in this report presents estimates of the proportion of 1987 doctorate recipients who were in the United States in 1997, but not in 1992. To produce this table, the Social Security Administration was asked to provide a more complex tabulation than was used for a simple stay rate estimate. As with other estimates in this report, the raw data received from the Social Security Administration were adjusted by taking into account the responses of a comparison group of U.S. citizens who received doctorates in the same disciplines and year. There was little problem estimating the proportion of the U.S. citizens who graduated in 1987 and were not in the United States in 1992. However, to make the adjustment required for Table 10, it was necessary to know or to estimate how many U.S. citizens who graduated in 1987 and were outside the United States in 1992 had returned to the United States and earned at least \$5,000 here in 1997.

An example will illustrate the difficulty with regard to missing information. Consider the temporary residents receiving life sciences doctorates in 1987. Methods described above produced an estimate that 44 percent were in the United States in 1997. How many of those here in 1997 were not here in 1992? Using raw tabulations from the Social Security Administration, we know that 16.7 percent of those who paid taxes on at least \$5,000 of earnings in 1997 did not do so in 1992. However, it would be a mistake to use this without an adjustment. A control group of similar U.S. citizens were examined, and it was found that even among U.S. citizens 4.5 percent of those who paid Social Security taxes on \$5,000 or more in 1997 did not do so in 1992. If we could assume that these U.S. citizens were in the United States in 1992 but weren't paying taxes (e.g., because they did not work or they worked in certain state government jobs) then it would be reasonable to subtract the 4.5 percent for the U.S. citizens from the 16.7 percent rate from

the persons who were temporary residents. This could produce an estimate that 12.2 percent of the temporary resident doctorate recipients of 1987 who were here in 1997 had not been here 5 years earlier. However, this is not a reasonable assumption as U.S. citizens go abroad, and this is one reason why they don't all pay social security taxes.

NSF estimated that among those who were native-born U.S. citizens with an S/E doctorate, 3.3 percent were abroad in 1995.<sup>10</sup> While this estimate itself has a margin of error, it is the best available estimate of the extent to which U.S. citizens with doctorates in an S/E field reside outside the United States. There is no information available on the rate at which U.S. citizens residing abroad tend to return to the United States. Some are expatriates who stay abroad for many years, but many are on temporary work assignments of less than 5 years, e.g., a sabbatical, a postdoctoral appointment, or a temporary company transfer. A very high proportion of those U.S. citizens on temporary assignments of less than 5 years who were out of the United States in 1992 could be expected to be back in the United States in 1997. However, any specific proportions would be guesses as there is no data available. Table A-2 shows the result of two different assumptions. The low-case estimate assumes that only 40 percent of all U.S. citizens in the cohort who were abroad in 1992 returned to the United States to earn at least \$5,000 in 1997. The high-case estimate assumes that 90 percent of them returned to the United States. The mid-case estimate in Table A-2 is the average of the high and low estimates. The high and low cases are never more than 1 percentage point different from the mid-case estimates. The mid-case estimates are the only ones reported in Table 10 in the body of this report.

**Table A-2. Temporary Residents Receiving S/E Doctorates from U.S. Universities in 1987 Who Were in the United States in 1997 but not in 1992, by Case Scenario**

	Temporary Resident Doctorate Recipients	Percent		
		Low	Mid-Case	High
All S/E	4,032	7	8	9
Physical sciences	923	5	6	7
Life sciences	877	13	14	15
Social sciences	700	3	4	5
Engineering	1,532	6	7	8

Source: Oak Ridge Associated Universities.

## ENDNOTES

<sup>1</sup>As explained in the Technical Appendix, these are estimates of the proportion of foreign-born doctorate recipients who stay for any reason in the United States. While our basic data consist of the proportion in a specified group of foreign-born doctorate recipients who paid Social Security taxes on at least \$5,000 of earnings in a given year, there is an upward adjustment of these proportions to account for persons who were not employed or were employed in jobs not covered by Social Security.

<sup>2</sup>Sampling was based on country of citizenship, and occurred only when a country accounted for more than 250 of the doctorates in one of the broad degree field categories shown in Table 1. See Technical Appendix for a more complete description.

<sup>3</sup>See Michael G. Finn, 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. The methodology of this earlier study is identical to the present one, so comparisons are valid.

<sup>4</sup>National Science Foundation, Selected Data on Science and Engineering Doctorate Awards: 1994, NSF 95-337 (Arlington, VA, 1995), Table 4.

<sup>5</sup>National Science Foundation, Division of Science Resources Studies, Science and Engineering Doctorate Awards: 1997, NSF 99-223, Author: Susan T. Hill, (Arlington, VA, 1999). Table 5.

<sup>6</sup>Our method compares the unadjusted stay rate for foreign nationals with the unadjusted stay rate of U.S. citizens. The fact that some postdocs do not pay Social Security taxes would not cause error if the same were true of the control group. However, more of the foreign nationals take postdocs compared with their U.S. counterparts and this, together with underpayment of social security taxes, can cause an underestimate of the stay rate in the first few years after receipt of the doctorate.

<sup>7</sup>These were published in National Research Council, Biomedical and Behavioral Research Scientists: Their Training and Supply, Volume I, Washington, DC: National Academy Press, 1989, p.114.

<sup>8</sup>Telephone conversation with Mr. Ken Sanders of the Social Security Administration, July 1994.

<sup>9</sup>National Center for Education Statistics, State Higher Education Profiles, Washington, DC, 1993 (NCES 93-169).

<sup>10</sup>National Science Board, Science and Engineering Indicators, 1998, pp. 3-21.

## REFERENCES

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

Michael G. Finn, 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 Center for Education Statistics, State Higher Education Profiles, Washington, DC, 1993 (NCES 93-169).

National Research Council, Biomedical and Behavioral Research Scientists: Their Training and Supply, Volume I, Washington, DC: National Academy Press, 1989, p. 114.

National Science Board, Science and Engineering Indicators – 1998. Arlington, VA: National Science Foundation, 1998 (NSB 98-1).

National Science Foundation, Division of Science Resources Studies, Science and Engineering Doctorate Awards: 1997, NSF 99-323 Author, Susan T. Hill (Arlington, VA 1999).

National Science Foundation, Division of Science Resources Studies, Science and Engineering Doctorate Awards: 1998, NSF 00-304 Author, Susan T. Hill (Arlington, VA 2000).

National Science Foundation, Selected Data on Science and Engineering Doctorate Awards: 1994, NSF 95-337 (Arlington, VA, 1995).

U.S. Social Security Administration, Social Security Programs in the United States, Social Security Administration, Office of Research, Evaluation and Statistics, July 1997 (SSA Publication No 13-11758) [www.ssa.gov/sspus](http://www.ssa.gov/sspus).