

Stay Rates of Foreign Doctorate Recipients from U.S. Universities, 2003

Prepared by:

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

November 2005

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 (S/E) doctorates from U.S. universities in 2001 lived in the United States in 2003.
- The two-year stay rate increased substantially during the 1990s, but has leveled off at 71 percent.
- The five-year stay rate increased to its highest level yet: 67 percent of the 1998 doctorate recipients were in the United States in 2003. This is up slightly from a 65 percent rate observed two years earlier for the 1996 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) remained at 68 percent in 2003, after increasing from 41 percent in 1989 to 68 percent in 2001.
- Among S/E disciplines, the highest stay rates were recorded for computer/electrical and electronic (EE) engineering and the physical sciences. The stay rates in agricultural sciences, 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 (90 percent) and India (86 percent) are very high, while Taiwan (47 percent) and Korea (34 percent) are well below the average for all countries.
- A one-year stay rate for 2002 doctorate recipients was compared with one-year stay rates from earlier years, which showed a slight decline in the stay rate. Reports of intentions to stay from the classes of 2002 and 2003 also indicate that stay rates may have started to decline slightly.
- Long-term stay rates were estimated for foreign students receiving S/E doctorates in 1993. About 58 percent were in the U.S. in 2003. A larger proportion, about 68 percent, paid taxes on U.S. earnings during at least one of the years between 1995 and 2003.

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 and is always specific to a particular year. Each line in the tables that follow describes a different group of these degree recipients.

Data and Methods

The stay rate estimates were 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 for the year(s) specified, 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 2001 foreign doctorate recipients in 2002 and 2003. This table contains information on all foreign students, including those with permanent resident and temporary visas at the time of graduation. Table 1 indicates that the 2003 stay rate for S/E doctorates is quite high at 71 percent overall. In comparison, the 2003 stay rates in the agricultural and social sciences are lower, around 50 percent. The highest stay rates were recorded in the physical sciences, 78 percent in 2003, and in computer/EE engineering, 80 percent in 2003.

**Table 1. Percentage of Foreign Students Receiving S/E Doctorates in 2001
Who Were in the United States, 2002-2003
(includes students on temporary and permanent visas)**

Degree Field	Foreign Doctorate Recipients	Percent in the United States	
		2002	2003
Physical science	1,686	80	78
Mathematics and computer sciences	907	77	75
Agricultural science	387	52	51
Life science	1,975	78	75
Computer/EE engineering	988	84	80
Other engineering	2,098	77	72
Economics	640	47	44
Other social science	787	58	57
Total, all fields	9,468	74	71

Source: Oak Ridge Associated Universities.

While the stay rates shown in Table 1 are at an all-time high, Figure 1 indicates this is the first time in recent years that the two-year stay rate has failed to increase. After increasing from 49 percent in 1989 to 71 percent in 2001, the two-year stay rate has stayed at 71 percent.

Figure 1. Percentage of Foreign Students Receiving S/E Doctorates Who Were in the United States Two Years After Graduation, 1989-2003

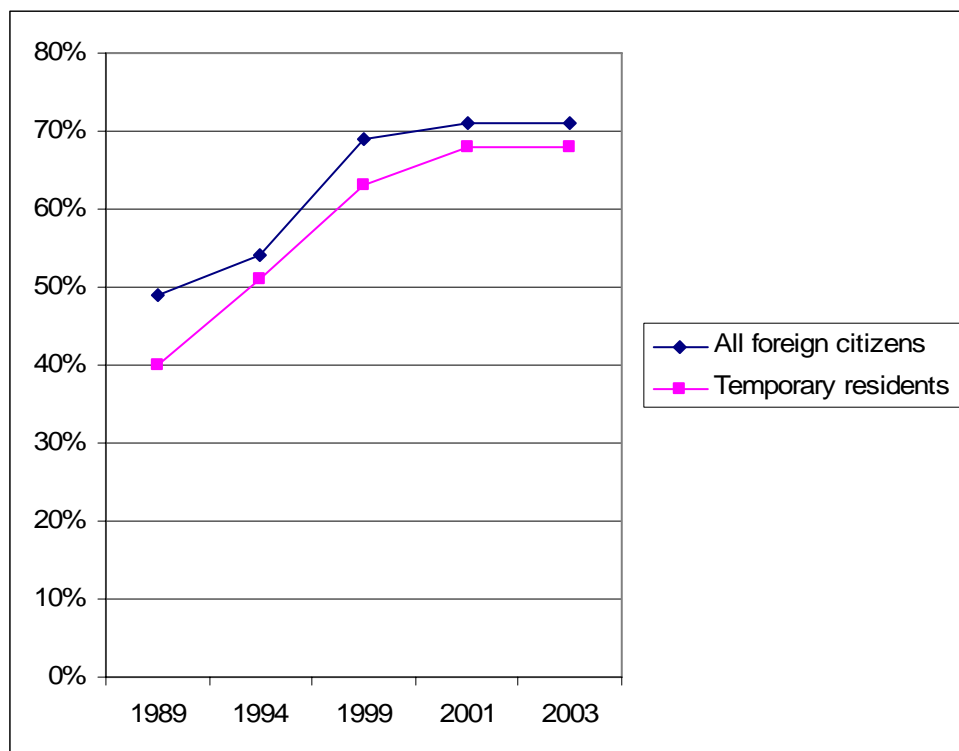


Table 2 shows the number of S/E doctorates awarded, by citizenship status. The number of doctorate awards grew substantially from 1987 to 1992. However, the number awarded in 2003 shows virtually no growth when compared with the number awarded 11 years earlier, and this is true for both U.S. citizens and foreign citizens.

Table 2. Science and Engineering Doctorates Awarded by U.S. Universities, by Citizenship Status, Selected Years, 1987-2003

Citizenship Status	1987	1992	1997	1999	2001	2003
Temporary visa	4,468	8,092	7,509	7,238	7,959	8,388
Permanent visa	1,089	1,383	2,281	1,653	1,278	1,098
Total, foreign citizens	5,557	9,475	9,790	8,891	9,237	9,486
U.S. citizens	12,966	14,559	16,112	15,912	15,060	14,571

Source: National Science Foundation, Science and Engineering Doctorate Awards: 1996, and Science and Engineering Doctorate Awards: 2003, (NSF 97-329) and (NSF 05-300).

The stay rate in 2003 was slightly lower for persons who received their doctorates in earlier years. Table 3 shows that the stay rate for foreign students receiving doctorates in 1998 was 67 percent. Note however, that the stay rate for this class in 2000, two years after their graduation, was 70 percent. The stay rate for this class declined only 3 percentage points during the first five years after graduation – even though the last year, 2003, was a poor year for job seekers. This is significant because many new doctorates take postdoctoral research appointments, but only a fraction of them 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

**Table 3. Percentage of Foreign Students Receiving S/E Doctorates in 1998
Who Were in the United States, 1999-2003
(includes students on temporary and permanent visas)**

Degree Field	Foreign Doctorate Recipients	Percent in the United States				
		1999	2000	2001	2002	2003
Physical science	1,795	78	78	78	76	74
Mathematics	540	70	69	66	67	64
Computer science	413	76	75	76	76	75
Agricultural science	543	51	51	50	51	51
Life science	2,254	75	75	74	73	74
Computer/EE engineering	847	81	81	78	77	76
Other engineering	2,214	71	72	70	69	68
Economics	614	45	45	44	41	42
Other social science	803	48	49	48	48	49
Total, all fields	10,023	70	70	68	68	67

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 2001 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

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 2 to 10 years after graduation as well. The 2003 stay rate for all S/E doctorates awarded by U.S. universities to foreign citizens in 1993, 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, 1995 to 2003. 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

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.

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 1993 give us some insight into this phenomenon.

Table 4. Percentage of Foreign Students Receiving S/E Doctorates in 1993 Who Were in the United States, 1995-2003
(includes students on temporary and permanent visas)

	Foreign Doctorate Recipients	Percent in the United States								
		1995	1996	1997	1998	1999	2000	2001	2002	2003
Physical science	2,271	69	69	69	69	70	69	70	69	67
Engineering	2,568	54	54	54	54	55	56	56	55	54
Life science	1,827	65	64	66	67	67	68	69	68	68
All other science	3,035	47	47	47	47	48	48	49	48	48
Total	9,701	58	57	58	58	59	59	59	58	58

An examination of raw, i.e., unadjusted data, suggests that the stay rate for the class of 1993, which was 58 percent in 2003, would be 17 percent higher if the rate were to represent the proportion who had worked in the United States for at least one year during the 1995 to 2003 period. This indicates that at least 68 percent of the foreign citizens who received S/E doctorates from U.S. universities in 1993 worked in the United States for at least one year. Or put another way, for every six foreign doctorate recipients from the class of 1993 who were here in 2003, there was one more that had worked here sometime during 1995-2002 but was no longer here in 2003.

Stay Rates for Temporary Residents

The previous discussion 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 combines those on permanent visas 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 as it 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 2001. The overall stay rate shown for all S/E degree fields in Table 5 is 68 percent in 2003. 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 five-year stay rate for students on temporary visas when they received their doctorates in 1998.

Table 5. Percentage of Temporary Residents Receiving S/E Doctorates in 2001 Who Were in the United States, 2002-2003

Degree Field	Foreign Doctorate Recipients	Percent in the United States	
		2002	2003
Physical science	1,465	79	77
Mathematics	436	72	70
Computer science	360	78	74
Agricultural science	359	50	49
Life science	1,562	76	72
Computer/EE engineering	899	83	79
Other engineering	1,888	76	70
Economics	579	44	41
Other social science	594	51	50
Total, all fields	8,142	72	68

Source: Oak Ridge Associated Universities.

Table 6. Percentage of Temporary Residents Receiving S/E Doctorates in 1998 Who Were in the United States, 1999-2003

Degree Field	Foreign Doctorate Recipients	Percent in the United States				
		1999	2000	2001	2002	2003
Physical science	1,419	75	74	72	71	69
Mathematics	447	67	63	62	60	59
Computer science	328	71	71	72	72	70
Agricultural science	463	48	47	47	47	46
Life science	1,620	72	68	67	68	67
Computer/EE engineering	688	78	76	75	74	70
Other engineering	1,894	69	67	67	65	64
Economics	516	40	39	37	37	36
Other social science	583	39	38	37	37	37
Total, all fields	7,958	66	64	63	62	61

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 61 percent in Table 7 as opposed 67 percent in Table 3. Table 7 shows that four countries continue to 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 2003 stay rate for Chinese doctorate recipients in Table 7, 90 percent, is the highest observed for any country in 2003. While this is slightly lower than the stay rate observed for Chinese students in the recent past, it is still very high. This indicates a lower rate of students returning to China that has been observed more generally for the return of Chinese students and scholars who left China for foreign study. [Cheng Li, 2005] Li's report of higher return rates refers to students in all disciplines and all countries so these findings are not necessarily in conflict with the stay rates reported here. Nevertheless, if China is encouraging the return of scholars and is in fact experiencing substantial return from other countries and from scholars undertaking shorter courses of study than that required by a U.S. doctorate degree, it is difficult to explain why the stay rate for S/E doctorate recipients from U.S. universities has remained as high as 90 percent. See Appendix A for a discussion of Li's data on Chinese returnees from the United States.

Not all of the large source countries for foreign students display high stay rates in Table 7. Taiwan's stay rate was only 47 percent in 2003, and South Korea's only 34 percent during the same period. Other countries with low stay rates include Indonesia (19 percent), Japan (37 percent), and Brazil (25 percent) in 2003. Other countries with above average rates in 2003 include Argentina (69 percent), Iran (82 percent) and Eastern Europe countries combined (83 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, Brazil and Japan have had the three lowest stay rates, and each of these countries has had the lowest stay rate at least once during the six time periods examined. The overall pattern is one of stability in term of country rankings. However, Taiwan and the United Kingdom have had stable stay rates while the other countries have experienced increasing stay rates.

The stay rate for Canadian doctorate recipients increased somewhat more than the overall stay rate for all countries over the period examined in Table 8. Given the large influx of science and engineering students from Asia to the United States, it seems plausible that some of the Canadian stay rate increase could be due to a two-stage migration process. That is, students from outside North America might first migrate to Canada and then come to the United States. It is possible that these immigrants to Canada would be more likely to stay in the United States after the doctorate than other Canadians who were born in Canada. To test for this the Canadian stay rate was re-calculated separately for those Canadians who were not born in Canada and for all other Canadians. Those born outside of Canada made up 24 percent of the 1998 Canadian doctorate recipients from U.S. universities in 1998. Their stay rate in 2003, however, was only slightly higher than the stay rate of other Canadians, 63 vs. 56 percent. One must conclude that, while there is two-stage migration to the United States via Canada, this does not have a substantial impact on the Canadian stay rate statistics because the Canadian stay rate is almost as high for native Canadians as for those born outside Canada.

**Table 7. Percentage of Temporary Residents Receiving S/E Doctorates in 1998
Who Were in the United States, 1999-2003**

Country of Origin	Foreign Doctorate Recipients	Percent in the United States				
		1999	2000	2001	2002	2003
China	1,757	92	92	92	92	90
Taiwan	868	58	53	51	49	47
Japan	125	36	38	36	38	37
South Korea	744	48	43	39	37	34
India	1,047	89	89	87	86	86
Other East Asia	212	31	29	28	27	24
Iran	56	85	81	87	81	82
Israel	36	38	35	35	41	42
Turkey	153	52	49	45	47	48
Other West Asia	338	50	49	49	47	47
Australia	42	43	35	37	35	40
Indonesia	60	23	19	21	21	19
New Zealand	25	40	31	31	36	36
Other Pacific/Australasia	62	56	54	52	51	53
Egypt	80	46	42	39	39	38
South Africa	41	45	40	37	40	43
Other Africa	191	58	54	51	50	46
Greece	95	61	57	61	59	60
United Kingdom	83	71	65	67	65	60
Germany	172	51	50	48	50	51
Italy	75	42	42	43	45	45
France	53	58	58	54	54	54
Spain	51	42	40	40	38	38
Other EU countries	242	54	51	51	50	47
Other Europe, East	365	85	85	85	84	83
Other Europe, West	36	40	33	33	40	37
Canada	228	58	58	58	59	58
Mexico	167	28	23	26	23	20
Argentina	68	66	67	64	73	69
Brazil	157	26	26	26	26	25
Chile	19	42	36	30	36	37
Colombia	25	43	34	34	30	30
Peru	31	48	48	55	55	55
Other Central South America	180	44	45	48	47	48
Total, all countries	7,870	66	64	63	62	61

Source: Oak Ridge Associated Universities.

Table 8. Percentage of Foreign Students on Temporary Visas Receiving S/E Doctorates Who Were in the United States 4 to 5 Years after Graduation, for Selected Years, 1992-2003

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	1998 Doctorate Recipients in 2003
China	65	88	92	91	96	90
India	72	79	83	87	86	86
United Kingdom	na	59	56	60	53	60
Canada	32	46	48	55	62	58
Greece	44	41	46	49	53	60
Germany	na	35	38	53	48	51
Taiwan	47	42	36	42	40	47
Japan	17	13	21	27	24	37
Brazil	13	25	15	21	25	25
Korea	17	11	9	15	21	34
Average, all countries	41	47	53	51	56	61

Source: Oak Ridge Associated Universities.

Impact on Labor Supply

The U.S. workforce has come to depend on increasing numbers of foreign doctorates who are educated in U.S. universities and then stay in the United States to work. A previous study noted that from 1987 to 1999 there was an increase in both the number of foreigners earning doctorates at U.S. universities and the proportion who stayed here to work. It was estimated that of the approximately 3,600 person increase in labor supply from foreign doctorates that chose to stay in the United States over this 12-year period a little more than half resulted from the increasing stay rate with the remainder resulting from the increasing number of doctorates awarded to foreigners. (Finn, 2003)

However, data presented here show that the two-year stay rate has stabilized at 71 percent after having increased steadily during the 12 years from 1987 to 1999. This eliminates one source of the growth in labor supply. We might ask how significant this is in the larger picture.

As previously noted there was an increase of about 300 doctorates per year entering the work force during the period 1987 to 1999. This number may seem small but was not the total number of foreign doctorates staying, rather the increase in the number staying that occurred, on average, each year. Of that 300, about 140 would have occurred even if there was no increase in the stay rate and about 160 came from the rising stay rate. Since 1999, the increase in number of foreign doctorate recipients has slowed somewhat. From 1999 to 2001, the number of doctorates awarded to foreign persons who were still here in 2003 increased at a somewhat lower rate of 123 per year. Since there was no increase in the stay rate, this was the total increase in the number foreign doctorates staying in the United States two years after graduation.

Cutting the contribution to the growth in the S/E doctorate work force from 300 per year to less than 125 per year is a significant decline. However, from 1999 to 2003 the number of doctorates awarded to U.S. citizens dropped from 15,912 to 14,571, so the modest growth in foreign doctorate recipients who stay has not been enough to offset the larger decline in doctorate awards to U.S. citizens.

Indicators of Future Stay Rates

This report measures the stay rate of foreign doctorate recipients two and five years after graduation. It appears clear that the increase in stay rates that has gone on for over a decade has ended. Our two-year stay rate shows no change from the rate observed two years earlier. The five-year stay rate is at an all-time high. However, there is evidence that stay rates are influenced not so much by current conditions as by conditions prevailing at graduation. Thus, if the trend in stay rates levels off or even reverses towards a decline we might expect the five-year stay rate to be five years behind. The five-year and longer stay rate estimates are useful to test whether stay rates fall off from the rates experienced two years after graduation, but they likely to be late in showing a fall off in stay rates that occurs soon after graduation.

Since there is a possibility that stay rates have not only leveled off but are beginning to turn downward, an examination of data that would serve as early indicators of any such move is of interest. One such data source is to construct a one-year stay rate using the same data as has been used earlier in this report but focusing on the stay rate of 2002 graduates in 2003. Table 9 shows such a one-year stay rate and shows the comparable one-year stay rates for several earlier classes. Table 9 is confined to persons who had temporary visas at the time of graduation. Like Figure 1, above, however, this table shows that the 2-year stay rate leveled off (but did not decline) between the classes of 1999 and 2001. However, the stay rates after one year peaked with the class of 2001. The one-year stay rate for the class of 2002 was 69 percent, a decline of 3 percentage points. While we have no data to indicate what the two-year stay rate was for the class of 2002, we observe that in recent years the two-year stay rate has been slightly below the one-year rate. If this pattern was continued in 2004, then the two-year stay rate has declined; because we can observe only the one-year stay rate for the class of 2002, we can't be certain this has happened.

Table 9. Percentage of Foreign Students Receiving S/E Doctorates in 2002 and Earlier Years Who Were in the United States, One and Two Years After Graduation
(includes only students on temporary visas)

Year of Graduation	Percent in the United States After One Year	Percent in the United States After Two Years
2002	69	n.a.
2001	72	68
1999	70	68
1997	65	63

Another source of information about future stay rates is the “intentions” reports that can be generated from the Survey of Doctorate Recipients. Respondents fill out the survey about the time of graduation and are asked about plans for work or postdoctoral study after graduation. Those who report that they plan to work or study in the United States, and further that they have already signed a contract or have a definite commitment of employment, are described as having “definite plans to stay” in Table 10. Others who intend to stay in the United States but did not yet have such a commitment are included in the broader “plans to stay” category in the same table. By either definition, the data in Table 10 indicate slightly declining intentions to stay after a long rise to a peak in 2001. Table 9 data showed evidence of an actual decline in stay rates after the class of 2001 and the data in Table 10 suggests that a trend towards slightly declining stay rates continued with the class of 2003. Thus, it appears that two-year stay rates may actually be declining. This is not documented in this report because our most recent observation is for the class of 2001 in 2003, and the two-year rate for that class showed no sign of decline. However, when data become available to document the two-year stay rate for more recent classes, the intentions data in Table 10 indicate that the actual stay rates for the class of 2003 in 2005 will likely be slightly lower than the rates observed for the class of 2001 in this report.

Table 10. Percentage of Foreign Doctorate Recipients Reporting Plans to Stay in the United States After Graduation, 1994-2003

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Definite Plans to Stay	34	35	42	44	46	49	49	54	52	48
Plans to Stay	62	65	67	68	67	70	71	74	73	71

Source: Special Tabulation of Data from the Survey of Doctorate Recipients, prepared by National Opinion Research Center

Conclusions

This paper documents a strong trend of increasing stay rates for foreign doctorate recipients in S/E fields, but in recent years, the increases in the stay rates have leveled off and appear, indeed to have peaked and to be heading slightly lower. This is not yet evident in the five-year stay rates because stay rates are largely a function of the conditions prevailing at the time of graduation. The leveling off of stay rates is, however, quite evident in the two-year stay rate data. Finally, data on the one-year stay rate indicate a slight recent decline in stay rate behavior. This indication of decline, while small, is confirmed by stated plans of recent doctorate recipients.

Stay rates continue to vary substantially by country of origin and, and to a lesser extent, by discipline.

Appendix A

Other Data on Chinese Returning to China

A recent book edited by Cheng Li of Hamilton College focuses on U.S.-China Educational Exchanges, 1978-2003 and contains two chapters with information about returnees to China from U.S. Ph.D. programs. These are reviewed here with the aim of assessing the degree to which they are consistent with the high stay rates of Chinese Ph.D.s reported in the main body of this paper.

Chapter 4 is entitled “Coming Home to Teach: Status and Mobility of Returnees in China’s Higher Education. He reports that a total of 700,200 citizens of the People’s Republic of China (PRC) studied abroad during the 1978 to 2003 period, and that 172,800 of them have already returned – including more than 20,000 in 2003 alone. He calls this “a tidal wave of returnees from studies overseas,” and cites China’s robust economic growth, improvement in its socio-political conditions in recent years, growing integration with the world economy, and governmental policy initiatives as some of the factors contributing to this increase. Because the returnees seem to have the greatest impact on higher education in China, he explores this in some depth. Of most interest to the stay rate issue are the data he developed on the faculty at China’s top 25 universities. Examining faculty resumes, he identified over 3,000 returnees at this group of top universities. However, the data indicate that most studied abroad for only one to three years. Many were scholars who engaged in postdoctoral study or who had other relatively short periods of work/study abroad without earning formal degrees. Overall, the most common country for study abroad of returnee professors was the U.S., followed by Japan, Germany, and the UK. However, he found only 603 returnees with foreign Ph.D.s. He reports on the country of study for 370 of these and indicates that 141 studied in the U.S. A similar study of senior administrators at a larger group of Chinese universities examined by Li shows only 12 senior administrators with U.S. Ph.D.s out of 639 total senior administrators who had studied abroad long enough to be classified as returnees.

Data from the NSF’s Survey of Earned Doctorates indicate that 31,344 persons from China were awarded doctorate degrees from the time of the first Chinese doctorates in the early 1980s through 2002. I estimate that the average stay rate for all these years was around 90 percent, so that about 3,100 could have returned to China. This number excludes those who had permanent U.S. visas at graduation. Because of this and because some people work part of the year in both the U.S. and China, my stay rate estimates suggest that number of Chinese returnees with U.S. Ph.D.s could be even somewhat higher than 3,100. However, since some undoubtedly leave the U.S. for countries other than China, I would not expect it to be much higher than 3,100. It’s difficult to know what proportion of these to find in China’s top 25 universities, but the numbers reported by Li would not account for even 10 percent of the number I estimate to have returned. Li would have to report much higher numbers to suggest that a 90 percent stay rate in the U.S. is implausibly high.

Chapter 6 in Li’s book includes a case study, by Shiping Zheng, of a program that brought Chinese scholars to U.S. universities to pursue graduate studies in international relations. The program was run under the auspices of the Committee on International Relations Studies with the People’s Republic of China (CIRSPRC), and the CIRSPRC’s sole mission was “to strengthen China’s principal institutions of international relations research, training, and policy analysis while promoting collaboration between American and Chinese specialists.” In all, 61 graduate students were supported for study at U.S. universities: 31 in M.A. programs and 30 in Ph.D. Programs. Another 54 were visiting scholars in the U.S. for a year or less. Zeng reports that the return rates were high for the visiting scholars, lower for the master’s students and lowest for the Ph.D. students. In fact, Zeng, who was one of the 30 Ph.D. students and is now a professor in the U.S., undertook to locate the former program participants and could only identify 4 out of the 30 as having returned to China. This is a very small case study, but it is entirely consistent with my findings of an overall stay rate of about 90 percent for Chinese doctoral recipients from U.S. universities.

These two chapters from Li's book suggest that there have been a large number of returnees to China from academic study abroad but that most of the returnees have been persons who were visiting scholars for short periods of time or who earned master's degrees rather than doctorates. The numbers of Chinese doctorate recipients from U.S. universities actually counted as being in China today is not inconsistent with the high stay rates for Chinese reported in this paper.

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 116 groups of Ph.D. recipients who received S/E degrees from U.S. universities in 1993, 1998, 2001, and 2002.

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 1998 with a degree in one of the physical sciences). 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 1,656 persons from China who were shown by the NORC to have received doctorates from U.S. universities in 1998. The Social Security Administration found that none of these had Social Security numbers that were invalid but 26 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 1,630 with presumed valid Social Security numbers. The Social Security Administration reported that 1,454 of the 1,630 individuals were recorded as having earned \$5,000 or more in 2001. This can be used to calculate a stay rate of 1,454/1,630 or 89.2 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. In addition, it should be noted that no one who did not already have access to doctorate recipients' social security numbers (SSN) gained access to those numbers, including the author of this report.

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 one year. The primary concern that led to this birth year screen was the possibility that a Social Security number reported on the *Survey of Earned Doctorates* might be incorrect, yet would be treated by the Social Security Administration as valid if it was identical to one of the millions of numbers in the system. By requiring the birth year to match or be off by no more than one year, probably more than 95 percent of any such false matches were eliminated. Only 2.1 percent of foreign citizens had birth years that did not match within one year. A failure to match birth years in 2.1 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 identical to the 2.1 percent rate of non-matches found here for foreign citizens in this study, 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 is not 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 1995 to 2003. This produced only two 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. As a result Egypt was combined with Other Africa instead of being shown separately. Also, permanent residents receiving doctorates in 2001 in mathematics were combined with permanent residents receiving computer science doctorates to comply with the confidentiality rules.

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 some foreign graduates did not have Social Security numbers, even though the vast majority does. 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 SSNs recorded for a few graduates were never issued by the Social Security Administration. Table A-1 shows how the proportion missing valid SSNs varies by year of graduation and degree field.

Table A-1 shows that the highest percentages missing valid SSNs were observed among temporary residents with degrees in "other social science," and computer science. The percentage missing valid SSNs 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 SSNs more often than average.

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

	1998 Temporary Residents	2001 Temporary Residents	1998 Permanent Residents	2001 Permanent Residents
Total, All S/E	8.5	8.3	7.8	7.2
Physical science	7.8	7.3	8.5	6.8
Mathematics	8.1	8.5	10.8	6.3
Computer science	12.2	12.5	9.4	6.3
Agricultural science	9.8	8.4	11.3	0.0
Life science	7.2	7.5	4.7	6.8
Computer/EE engineering	7.7	8.7	7.5	6.7
Other engineering	6.6	7.2	9.7	7.1
Economics	12.5	9.4	5.1	13.1
Other social science	14.3	12.3	10.9	8.8

Source: Oak Ridge Associated Universities.

A low-case assumption could be made that all persons with missing or invalid SSNs 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 SSNs 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 SSNs in the same group. Making this adjustment had the result of reducing the stay rate by 1.8 percentage points for the 2001 cohort and by 2.6 percentage points for the 1998 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 SSNs 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 SSNs is that for doctorate recipients from Canada. The estimated stay rate for Canadians in Table 5 would be 5.9 percentage points higher if no adjustment had been made for missing and invalid numbers. This is the most extreme case. All others were adjusted by less than 3 percentage points.

While missing social security numbers do not seem to be a substantial source of error in these estimates, there is reason to be concerned that missing social security numbers are a bigger problem than they were in the past and they will become an even bigger problem in the future. For some years individuals concerned with privacy have been guarded about the use of their social security number. It appears that increasing numbers refuse to give their social security number when the provision of this number is not required. Further, universities seem to be moving away from the use of the social security number as a student identification number. When current graduate students complete their doctorates we may see a decreasing proportion agreeing to provide a social security number to the *Survey of Earned Doctorates*. In addition, effective October, 2004, foreign students with student (F-1) visas were prohibited from obtaining a social security number unless they provided evidence of work authorization. (U.S. Social Security Administration, 2004). This will cause a decrease in the number of foreign doctorate recipients

on temporary visas who have social security numbers. However, since few students complete a doctorate in less than four years, this will probably only begin to limit the availability of SSNs for temporary visa holders beginning with those completing doctorates around 2008.

After adjustment for missing SSNs, the proportion paying taxes on at least \$5,000 in covered earnings 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 death rates from the Period Life Table, 2000 published by the U.S. Social Security Administration (U.S. Social Security Administration, 2003). 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 2003. 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 2001 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 1998 graduates residing in the United States in 2003: 2.9 percent of them are estimated to have had earnings below the threshold. Similar sets of estimates were constructed for the 1993 graduates residing in the United States in 2003: 3.0 percent of them are estimated to have had earnings below the threshold.

Effect of the Adjustments

The adjustments for missing and invalid SSNs 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 5 shows a stay rate estimate for 2001 doctorate recipients in 2003. This decreased from 69.2 percent to 68.45 percent (rounded to 68 percent in Table 5) because of the net effect of adjustments. Table 6 shows a stay rate estimate for 1998 doctorate recipients in 2003. This decreased from 62.1 percent to 61.3 percent (rounded to 61 percent in Table 3) because of the net effect of adjustments. Table 4 shows a stay rate for 1993 doctorate recipients of 58 percent in 2003. This was virtually unchanged 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 two percentage points in nearly all cases. However there were a few fields where the adjustment changed rates by as much as 2.5 percent. For example, the relatively small category of 1998 graduates in agricultural science who were permanent residents -- this group happened to have an unusually high 11 percent without valid social security numbers. Our method assumed that the stay rate for those without social security numbers was half the calculated stay rate for others and this caused the relatively large adjustment.

The effect of adjustments was greatest for the country specific stay rates in Table 7. The stay rates for only three of the countries were changed by more than two percentage points as a result of adjustments. The stay rate for Canada would have been 4.3 percent higher if unadjusted rates were used; for Germany it would have been 2.4 percent higher; and for "Other Europe" it would have been 2.8 percent higher. Canada has the highest proportion of doctorate recipients without valid SSNs in the database. Whereas, overall, 92 percent of doctorate recipients reported valid SSNs to the *Survey of Earned Doctorates*, only 82 percent of those from Canada reported valid SSNs. It was not that Canadians reported invalid SSNs, they were just more likely to report no SSN at all. We do not know why Canadians are much less likely to report SSNs. However, we assumed that those without SSNs would stay at only half the rate as their countrymen who did report SSNs. This is why the estimates for Canada differ as much as 4.3 percent from the unadjusted data. The same is true, to a lesser extent, for Germany and for "Other Europe."

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.

There is an estimate on page 6 of this paper which addresses the issue of 1993 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 2003. Unadjusted data were used to estimate that the 2003 stay rate (58 percent) "would be 17 percent higher if the rate were to represent the proportion who had worked in the United States for at least one year during the 1995 to 2003 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 2003 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.

REFERENCES

Finn, Michael G. Stay Rates of Foreign Doctorate Recipients from U.S. Universities, 2001, Oak Ridge, TN: Oak Ridge Institute for Science and Education, 2003.

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.

Li, Cheng, Bridging Minds Across the Pacific: U.S.-China Educational Exchanges, 1978-2003, Lanham, MD: Lexington Books, 2005.

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

National Science Foundation, Science and Engineering Doctorate Awards – 2003, Arlington, VA (NSF 05-300).

U.S. Social Security Administration, Final Rule regarding regulations for F-1 Students to Obtain Social Security Numbers, Federal Register (Vol. 60, No. 176, p. 55065-55076).

U.S. Social Security Administration, Period Life Table 2000, 2003.