

Stay Rates of Foreign Doctorate Recipients from U.S. Universities, 2005

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Highlights

This study used 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:

- Two-thirds (66 percent) of foreign citizens who received science/engineering (S/E) doctorates from U.S. universities in 2003 lived in the United States in 2005.
- The two-year stay rate had peaked at 71 percent in the early part of this decade; thus the more recent 66 percent rate represents a decline in the stay rate of foreign doctorate recipients.
- The five-year stay rate increased to its highest level yet: 68 percent of the doctorate recipients in 2000 were in the United States in 2005. This is up only slightly from a 67 percent rate observed two years earlier for the 1998 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) declined to 64 percent in 2005, after increasing from 41 percent in 1989 to 68 percent in 2001 and 2003.
- Among S/E disciplines, the highest stay rate was recorded for computer/electrical and electronic (EE) engineering. The stay rates in agricultural sciences, economics, and the other social sciences were the lowest.
- Most foreign doctorate recipients come from the four largest source countries. The five-year stay rates vary dramatically for temporary residents from these four countries: China (92 percent) and India (85 percent) are very high, while Taiwan (50 percent) and Korea (42 percent) are well below the average for all countries.
- A one-year stay rate for 2004 doctorate recipients was compared with one-year stay rates from earlier years. This early indicator shows a slight rebound in the stay rate. Reports of intentions to stay from the class of 2005 also indicate that stay rates may have stopped declining.
- Long-term stay rates were estimated for foreign students receiving S/E doctorates in 1995. About 62 percent were in the United States in 2005. A larger proportion, about 75 percent, paid taxes on U.S. earnings during at least one of the years between 1995 and 2005.

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 who 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 2003 foreign doctorate recipients in 2004 and 2005. 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 2005 stay rate for S/E doctorates is quite high at 66 percent overall. In comparison, the 2005 stay rates in the agricultural and social sciences are lower, around 50 percent. The highest stay rate was recorded in the physical sciences, 77 percent in 2005.

Table 1. Percentage of Foreign Students Receiving S/E Doctorates in 2003 Who Were in the United States, 2004-2005
(includes students on temporary and permanent visas)

Degree Field	Foreign Doctorate Recipients	Percent in the United States	
		2004	2005
Physical science	1,642	78	77
Mathematics	486	70	70
Computer science	405	74	73
Agricultural science	427	54	50
Life science	2,049	75	72
Computer/EE engineering	981	72	70
Other engineering	2,195	67	64
Economics	656	44	42
Other social science	829	55	53
Total, all fields	9,670	68	66

Source: Oak Ridge Associated Universities.

Figure 1 indicates that the stay rate shown in Table 1 represents a decline from the recent past. After increasing from 49 percent in 1989 to 71 percent in 2001 and 2003, the two-year stay rate has now declined to 66 percent.

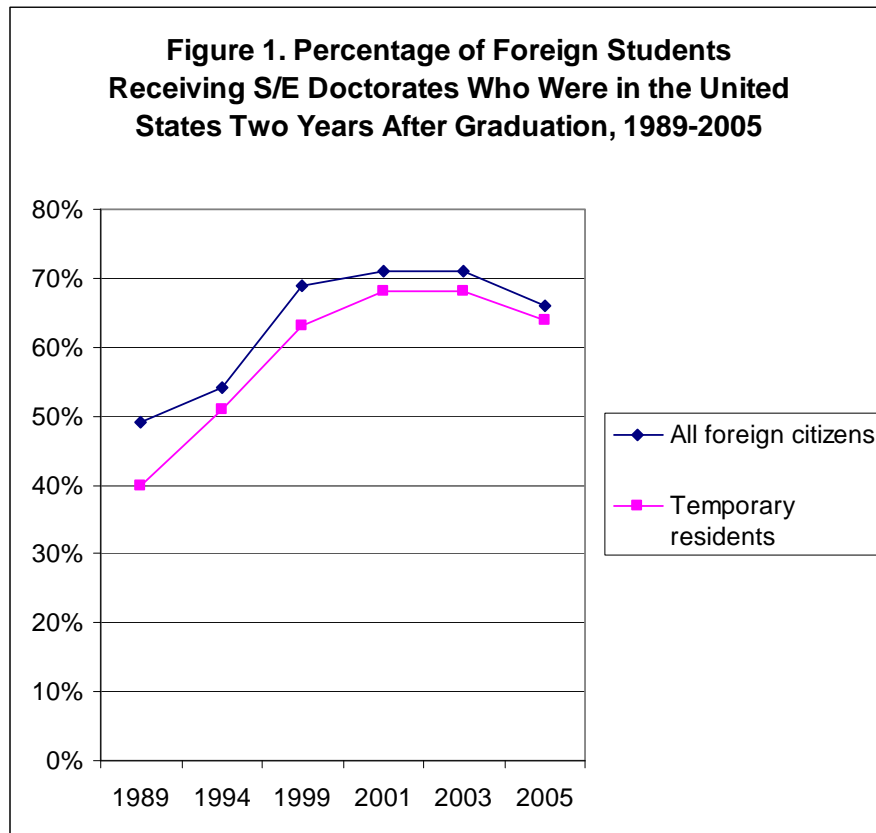


Table 2 shows the number of S/E doctorates awarded, by citizenship status. The number of doctorate awards grew substantially from 1987 to 1992. From 1997 to 2001, the awards to U.S. citizens declined. From 1997 to 2001, doctorate awards to foreign citizens declined as well. However, in the most recent period, from 2003 to 2005, doctorate awards to foreign citizens have increased dramatically.

Table 2. Science and Engineering Doctorates Awarded by U.S. Universities, by Citizenship Status, Selected Years, 1987-2005

Citizenship Status	1987	1992	1997	1999	2001	2003	2005
Temporary visa	4,468	8,092	7,507	7,238	7,943	8,382	10,404
Permanent visa	1,089	1,383	2,281	1,654	1,270	1,098	1,112
Total, foreign citizens	5,557	9,475	9,788	8,892	9,213	9,480	11,516
U.S. citizens	12,966	14,559	16,112	15,915	15,049	14,635	14,912

Source: National Science Foundation, Division of Science Resources Statistics. Science and Engineering Doctorate Awards: 1996, and Science and Engineering Doctorate Awards: 2005, (NSF 97-329) and (NSF 07-305). Susan T. Hill, project officer. Arlington, VA.

The stay rate in 2005 was slightly higher for persons who received their doctorates in earlier years than it was for those who graduated in 2003. Table 3 shows that the five-year stay rate for foreign students receiving doctorates in 2000 was 68 percent. Note, however, that the stay rate for this class in 2002, two years after their graduation, was 72 percent. The stay rate for this class declined only 4 percentage points during the first five years after graduation. 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 2000
Who Were in the United States, 2001-2005**
(includes students on temporary and permanent visas)

Degree Field	Foreign Doctorate Recipients	Percent in the United States				
		2001	2002	2003	2004	2005
Physical science	1,596	77	77	76	74	73
Mathematics	499	75	75	73	70	70
Computer science	432	81	81	78	75	73
Agricultural science	472	54	54	52	52	51
Life science	2,130	76	76	75	73	73
Computer/EE engineering	869	83	83	78	77	76
Other engineering	1,932	74	74	71	69	68
Economics	595	47	47	46	44	44
Other social science	781	57	56	56	56	54
Total, all fields	9,306	72	72	70	68	68

Source: Oak Ridge Associated Universities.

Table 3 also shows stay rates by degree field. The field differences are similar to the field differences shown for the 2003 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 fall only slightly during the first five years after graduation. Data in Table 4 indicate that this is true during the period two to ten years after graduation as well. The 2005 stay rate for all S/E doctorates awarded by U.S. universities to foreign citizens in 1995, 62 percent, is somewhat lower than the 2005 stay rates of more recent classes. However, the stay rate did not decline appreciably during the period examined, 1996 to 2005. This provides additional evidence about how stay rates increased in the 1990s. The increase has occurred almost entirely because more recent graduates have higher stay rates. There is no evidence that stay rates for any given class tended to increase as time since graduation increased. This would seem rather obvious if one viewed all persons who leave the United States as having left for good. However, that is not the case. There is a certain amount of churning going on with respect to past classes of foreign graduates of U.S. universities. Some leave after staying here for a while, and these are largely replaced by others who return to the United States after living abroad for a while. Data on the foreign citizens who earned doctorates in the United States in 1995 give us some insight into this phenomenon.

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

**Table 4. Percentage of Foreign Students Receiving S/E Doctorates in 1995
Who Were in the United States, 1996-2005**
(includes students on temporary and permanent visas)

Degree Field	Foreign Doctorate Recipients	Percent in the United States									
		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Physical science	2,673	68	67	68	68	68	69	68	68	68	66
Engineering	3,483	67	66	66	66	66	66	65	64	64	63
Life science	2,157	70	68	69	71	71	70	70	70	69	70
All other science	3,156	53	53	53	52	52	53	52	51	51	51
Total	11,469	64	63	63	64	64	64	63	63	62	62

An examination of raw, i.e., unadjusted data, suggests that the stay rate for the class of 1995, which was 62 percent in 2005, would be 21 percent higher if the rate were to represent the proportion who had worked in the United States for at least one year during the 1996 to 2005 period. This indicates that 75 percent of the foreign citizens who received S/E doctorates from U.S. universities in 1995 worked in the United States during at least one of the next ten years. Or put another way, for every five foreign doctorate recipients from the class of 1995 who were here in 2005, there was one more that had worked here sometime during 1996-2004 but was no longer here in 2005.

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 temporarily 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 produced only 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 2003. The overall stay rate shown for all S/E degree fields in Table 5 is 64 percent in 2005. This is only slightly less than the 66 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 2000.

Table 5. Percentage of Temporary Residents Receiving S/E Doctorates in 2003 Who Were in the United States, 2004-2005

Degree Field	Foreign Doctorate Recipients	Percent in the United States	
		2004	2005
Physical science	1,452	77	75
Mathematics	440	68	67
Computer science	355	72	70
Agricultural science	393	52	47
Life science	1,727	74	71
Computer/EE engineering	891	70	68
Other engineering	2,019	65	62
Economics	597	41	39
Other social science	671	50	47
Total, all fields	8,545	66	64

Source: Oak Ridge Associated Universities.

Table 6. Percentage of Temporary Residents Receiving S/E Doctorates in 2000 Who Were in the United States, 2001-2005

Degree Field	Foreign Doctorate Recipients	Percent in the United States				
		2001	2002	2003	2004	2005
Physical science	1,359	76	75	72	71	70
Mathematics	443	74	71	68	68	66
Computer science	363	79	76	72	70	71
Agricultural science	416	51	49	48	47	46
Life science	1,691	74	73	71	71	72
Computer/EE engineering	757	82	78	76	75	73
Other engineering	1,694	72	69	67	66	66
Economics	537	44	44	43	42	40
Other social science	582	51	50	49	48	48
Total, all fields	7,842	70	68	66	65	65

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 65 percent in Table 7 as opposed to 68 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 for India in 2001, 85 percent, is very high given that none of these were permanent residents at the time of graduation.

The 2005 stay rate for Chinese doctorate recipients in Table 7, 92 percent, is the highest observed for any country in 2005. This indicates a lower rate of students returning to China than 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 92 percent.

Not all of the large source countries for foreign students display high stay rates in Table 7. Taiwan's stay rate was only 50 percent in 2005, and South Korea's was only 42 percent during the same period. Other countries with even lower low stay rates include Saudi Arabia (4 percent), Venezuela (23 percent), Brazil (30 percent), and Mexico (31 percent). Countries with above average rates in 2005 include Iran (90 percent) and Eastern Europe countries combined (82 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 relatively stable stay rates while the other countries have experienced increasing stay rates.

**Table 7. Percentage of Temporary Residents Receiving S/E Doctorates in 2000
Who Were in the United States, 2001-2005**

Country of Origin	Foreign Doctorate Recipients	Percent in the United States				
		2001	2002	2003	2004	2005
China	2,071	95	94	92	92	92
Taiwan	645	60	57	52	52	50
Japan	149	40	41	41	39	39
South Korea	696	59	54	49	44	42
India	756	89	87	86	85	85
Other East Asia	212	26	23	20	19	16
Iran	41	92	87	85	85	90
Israel	30	33	29	29	33	33
Saudi Arabia	58	4	4	4	4	4
Turkey	248	52	52	49	48	49
Other West Asia	275	66	63	62	62	60
Australia	31	54	54	50	47	40
Indonesia	54	52	50	46	38	36
New Zealand	19	73	67	67	55	61
Other Pacific/Australasia	50	66	64	62	73	73
Egypt	70	58	51	48	46	50
Nigeria	10	64	65	65	65	65
South Africa	33	44	40	40	41	41
Other Africa	182	60	62	59	59	59
Greece	68	61	61	60	58	54
United Kingdom	68	67	69	64	58	58
Germany	168	56	54	52	51	49
Italy	72	50	49	48	43	46
France	64	69	65	65	59	59
Spain	46	53	58	51	49	56
Other EU countries	266	66	64	60	61	60
Other Europe, East	400	85	84	82	82	82
Other Europe, West	39	48	42	42	42	42
Canada	260	63	61	59	59	56
Mexico	193	32	29	29	30	31
Argentina	67	61	58	55	55	55
Brazil	125	35	32	30	27	30
Chile	36	49	52	49	46	49
Colombia	49	54	45	49	47	56
Peru	19	57	57	57	63	68
Venezuela	64	44	43	46	48	45
Other Central South America	140	55	52	51	52	51
Total, all countries	7,774	70	68	66	65	65

Source: Oak Ridge Associated Universities.

None of the countries shown in Table 8 have 2005 stay rates that are as low as the rates experienced by Japan, Brazil, and Korea in the earlier years covered in Table 8. However, Table 7 reports stay rates for Saudi Arabia and its stay rate, 4 percent in 2005, is extremely low.

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, 1992-2005

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	2000 Doctorate Recipients in 2005
China	65	88	92	91	96	90	92
India	72	79	83	87	86	86	85
United Kingdom	na	59	56	60	53	60	58
Canada	32	46	48	55	62	58	56
Greece	44	41	46	49	53	60	54
Germany	na	35	38	53	48	51	49
Taiwan	47	42	36	42	40	47	50
Japan	17	13	21	27	24	37	39
Brazil	13	25	15	21	25	25	30
Korea	17	11	9	15	21	34	42
Average, all countries	41	47	53	51	56	61	65

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 U.S. labor supply from foreign doctorates 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 stabilized at 71 percent after having increased steadily during the 10 years from 1989 to 1999, then fell slightly to 66 percent in 2005. (Figure 1.) This eliminates one source of the growth in labor supply (increasing stay rates). We might ask how significant this is in the larger picture.

Table 9 reports the average number of foreign national doctorate recipients staying in the United States. It combines data on doctorates awarded with stay rate data to address the impact on labor supply. For those concerned about meeting growing demands for new science and engineering doctorates, it is of little consequence whether the number of new graduates increases because of new doctorate awards vs. changes in the stay rate.

The first section of Table 9 describes the number of foreign doctorates staying from the two previous graduating classes, and how this has changed as we look back from year 2001 versus 2003 or 2005. These data clearly indicate that, when we look at two-year increments, the number of foreigners staying after receiving doctorates from U.S. universities has not declined in recent years, but has even increased slightly in the most recent period. These data are shown as annual averages.

The next two sections in Table 9 make the same comparison looking at five or ten years at a time. Whereas the data in the top section include only the two most recent cohorts for each year examined, the second set of data includes the five most recent cohorts for each year, and the final data include the 10 most recent cohorts. Looking at the second set, which describes the five most recent cohorts, we can see evidence of a slight decline observable in 2003. By 2005, part of that decline has recovered.

The last set, which describes the 10 most recent cohorts, shows virtually no change over the period examined, from 2001 to 2005.

Table 9. Average Annual Number of Foreign Doctorate Recipients Staying in the United States Over the Previous Two, Five and Ten Years, as Observed in 2001, 2003, and 2005

Stayers from the Previous Two Classes (*average annual number*)

2001	6,421
2003	6,239
2005	6,586

Stayers from the Previous Five Classes (*average annual number*)

2001	6,642
2003	6,279
2005	6,300

Stayers from the Previous Ten Classes (*average annual number*)

2001	6,319
2003	6,313
2005	6,355

If the concern is averting declines in the number of foreign national doctorate recipients staying in the United States, then the data in Table 9 should be reassuring. There is evidence of a modest decline when we look back at the most recent five classes but not when focusing on the most recent ten or two classes.

However, if one is concerned with growing this component of the nation's supply of scientists and engineers, the data in Table 9 are not encouraging. We know that the number of stayers increased dramatically in the 1980s and 1990s. So far this decade there has been little increase. It's true that doctorate awards to foreign nationals increased in 2004, 2005, and 2006, however, and if that is the beginning of a trend, then there may be reason to expect a growing number of stayers during this decade. (NSF, 2008)

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 occurred for over a decade has ended and has even been reversed somewhat. Our two-year stay rate shows a modest decline 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 has only recently reversed 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 evidence that two-year stay rates did turn downward, an examination of data that would indicate whether this is continuing 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 2004 graduates in 2005. Table 10 shows such a one-year stay rate for 2004 doctorate recipients and shows the comparable one-year stay rates for several earlier classes. Table 10 is confined to persons who had temporary visas at the time of graduation. This table shows that the two-year stay rate leveled off and then declined between the classes of 2001 and 2003. The stay rates after one year also turned down after the class of 2001. The one-year stay rate for the class of 2003 was 67 percent, a decline of 5 percentage points from the peak. However, the one-year stay rate for the class of 2004 recovered slightly to 68 percent. This likely indicates that the decline in two-year stay rates experienced during the first part of this decade was only temporary and will not continue.

It is plausible that the macroeconomic performance of the U.S. economy affects stay rates. It is also plausible that security measures undertaken by the United States after the 9/11 attacks affect stay rates. Both of these factors were negative in the years immediately after 2001. However, since 2003 the economy has improved. Also, the negative effect of tightened security measures on the movement of scientists seems to have lessened. Either or both of these could explain the modest increase in one-year stay rates shown in Table 10 for the class of 2004.

Table 10. Percentage of Foreign Students Receiving S/E Doctorates in 2004 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
2004	68	na
2003	67	64
2002	69	na
2001	72	68
2000	70	68
1999	70	68
1997	65	63

Another source of information about future stay rates is the intentions data that can be generated from the Survey of Earned Doctorates. 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 11. 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 11 indicate intentions to stay declined in 2003 but by 2005 had begun to turn up again. Of course, the intentions data do not mean that the stay rate of the 2005 class will, for certain, be higher than the stay rate of previous classes. However, the data in Table 11 do reinforce the suggestion from Table 9 data that the modest decrease in stay rates observed after 2001 was temporary and has been reversed.

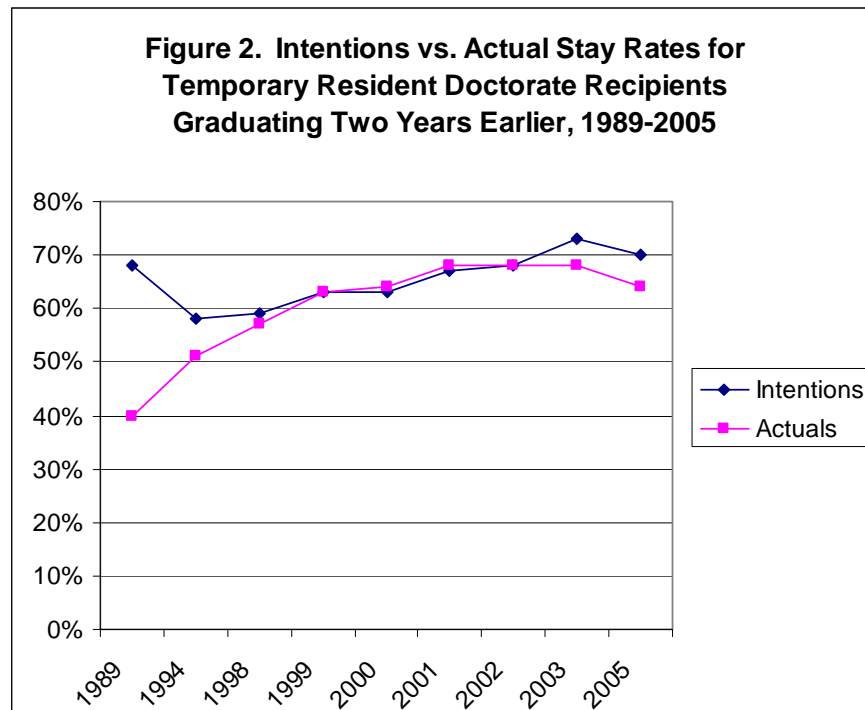
Table 11. Percentage of Foreign Doctorate Recipients Reporting Plans to Stay in the United States After Graduation, 1994-2005
(includes only students on temporary visas)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Definite Plans to Stay	30	31	38	42	44	47	49	54	51	48	47	50
Plans to Stay	52	53	59	63	63	67	68	73	71	70	70	74

Source: Special tabulation of data from the Survey of Earned Doctorates, prepared by National Opinion Research Center.

Intentions vs. Actual Stay Rates

How well have the stated intentions of new doctorates predicted their actual stay rates in the past? Figure 2 provides information on this question. During the first part of the period covered by Figure 2, the proportion of doctorate recipients stating that they intended to stay in the United States after graduation substantially exceeded the proportion that actually did stay. However, from 1998 to 2005, the actual stay rate has tracked the stated intentions fairly closely. Thus, the fact that the intentions data have moved to a new high for the class of 2005 (which would be shown as 2007 if graphed on Figure 2) provides sound reason to expect that the two-year stay rate will increase rather than decrease in the near future.



Note: The "Actual" stay rates are two-year stay rates reported elsewhere in this report. Thus, the data points for any given year reflect the intentions vs. the actual stay rate for the cohort receiving doctorates two years earlier.

Source: Special tabulation of the intentions data in the Survey of Earned Doctorates, provided by the National Opinion Research Center and Oak Ridge Associated Universities.

Conclusions

This paper documents a strong trend of historically increasing stay rates for foreign doctorate recipients in S/E fields, but in recent years, the increases in the stay rates peaked, then declined slightly. 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 slight decline in stay rates is, however, quite evident in the two-year stay rate data. Finally, data on the one-year stay rate indicate that the decline in stay rates was both slight and temporary; the latest one-year stay rate shows an increase. This indication of increase, while small, is confirmed by stated plans of recent doctorate recipients.

Looking at stay rates combined with degree awards also shows some evidence of a slight decline that has been partially reversed in the most recent period examined. However, while foreign doctorate recipients stayed in increasing numbers during the 1980s and 1990s, this no longer seems to be the case. These scientists and engineers still make up an important contribution to the United States, with over 6,000 graduating and staying annually. The only evidence that these numbers are growing substantially is the increase in degrees awarded to foreign nationals in 2004, 2005, and 2006. If this trend continues, the United States could benefit from a continuing increase in the number of foreign doctorates entering the U.S. labor force – even without a further increase in the stay rate.

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

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 106 groups of Ph.D. recipients who received S/E degrees from U.S. universities in 1995, 2000, 2003, and 2004.

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 2000 with a degree in one of the physical sciences). The NORC staff then prepared a data file 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 47,828 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 1,990 citizens of China who were shown by the NORC to have received doctorates from U.S. universities in 2000. The Social Security Administration found that three of these had Social Security numbers that were invalid and 24 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 1,963 with presumed valid Social Security numbers. The Social Security Administration reported that 1,774 of the 1,963 individuals were recorded as having earned \$5,000 or more in the United States in 2005. This can be used to calculate a stay rate of $1,774/1,963$ or 90.4 percent. Because this is a group statistic and no one outside of the Social Security Administration saw any individual earnings or tax data, the confidentiality of all the individuals in the group was preserved. 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 2.0 percent of foreign citizens had birth years that did not match within one year. A failure to match birth years in 2.0 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 2.1 percent of U.S. citizen doctorate recipients from recent graduating classes 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. This is almost identical to the 2.0 percent rate of non-matches found here for foreign citizens in this study. A more recent analysis of U.S. and non-U.S. doctorate recipients in 2004 found that the birth years of the DRF did not match those of the Social Security Administration for 1.9 percent of foreign nationals but for only 1.0 percent of U.S. citizens. We concluded that the difference between foreign and U.S. citizen doctorate recipients in this regard is less than one percent. 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 close to U.S. doctorate recipients in this regard, and because the number where there is not a birth year match is only 2.0 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 no groups where problems of confidentiality occurred. The practical application of the Social Security Administration's confidentiality rules meant that it would report no proportion if a group had a calculated proportion of 100 percent or 0 percent as this would permit the identification of individuals by persons who could match Social Security numbers with names (e.g., the NORC staff who prepared the groups sent to the Social Security Administration). Further, to be safe, the Social Security Administration staff would not calculate a proportion if all but three persons in a group had earnings of \$5,000 or more.

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

One reason for missing or invalid Social Security numbers is data error. Respondents to the *Survey of Earned Doctorates* may fail to write down their numbers or may record their numbers incorrectly, or coders 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. However, it is possible for students to go through graduate school without Social Security numbers. Some use a similar 9-digit ID number. 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. Some of the invalid Social Security numbers started with a 9, so it appears some students were confused and thought they were Social Security numbers. The Social Security numbers recorded for a few graduates were never issued by the Social Security Administration. It seems likely that in many of these cases the number was recorded incorrectly. However, in the vast majority of cases with missing Social Security numbers, no Social Security number was recorded by the National Research Council. Table A-1 shows how the proportion missing valid Social Security numbers varies by year of graduation and degree field.

The proportion of foreign citizens missing Social Security numbers increased dramatically from the class of 2000 to the class of 2003. While this has happened very recently, it was not a one-time event. The proportion missing Social Security numbers in 2004 was at a level similar to 2003. Increasingly individuals are advised that they need to guard these numbers quite closely in order to prevent identity theft. What appears to be the case is a substantial increase in the number of doctorate recipients who refuse to supply their Social Security number because of privacy concerns.

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

	2000 Temporary Residents	2003 Temporary Residents	2000 Permanent Residents	2003 Permanent Residents
Physical science	6.2	12.7	8.4	10.0
Mathematics	6.3	14.5	7.1	13.0
Computer science	7.7	17.8	2.9	8.0
Agricultural science	7.3	19.0	7.1	17.6
Life science	6.1	11.9	6.2	16.1
Computer/EE engineering	8.1	11.1	4.5	12.2
Other engineering	5.9	11.6	8.0	14.8
Economics	10.0	15.8	3.4	13.6
Other social science	6.7	16.5	11.1	15.2
Total, All S/E	6.5	13.2	7.2	13.9

Source: Oak Ridge Associated Universities.

There is no hard data indicating why the proportion of foreign national doctorate recipients providing Social Security numbers to the Survey of Earned Doctorates has declined. However, there is reason to believe that they, just like U.S. citizen doctorate recipients, increasingly want to restrict access to their Social Security number. Data obtained for all 2004 doctorate recipients indicate that 15.7 percent of U.S. citizens and 12.6 percent of non-U.S. citizens failed to supply Social Security numbers to the Survey of Earned Doctorates. That is, the increased tendency to decline to supply a Social Security number has been at least as great among U.S. citizens as among non-citizens.

The increased tendency for the most recent cohort not to provide a Social Security number is a cause for concern since it increases the possibility for error in the estimated stay rates provided in this report. Also, as the possibility for error increases, it becomes more important whether and how to adjust estimates for missing Social Security numbers.

Previous reports by the author have used one simple method to adjust estimates for missing Social Security numbers: it was assumed that those missing Social Security numbers stayed at only half the rate of those with those numbers. It seemed that some foreign nationals might be missing Social Security numbers in the Doctorate Record File because they were not seeking a position in the United States after graduation, and in some cases might never have acquired a Social Security number from the U.S. government. If this were true in all cases then the stay rate of those without Social Security numbers would be zero. If it were true in none of the cases, then the stay rate of the foreign doctorate recipients without Social Security numbers would likely be about as high as those who did report Social Security numbers. In the absence of information about the true reason for missing Social Security numbers it was decided to simply split the difference. Since the proportion of foreign nationals missing Social Security numbers was relatively small, usually between 4 and 6 percent, splitting the difference meant that the true stay rate was unlikely to be more than 1 or 2 percentage points different from the estimated stay rate on this account. By choosing a middle ground position it could be argued that no matter what the true stay rate was of those missing Social Security numbers the estimates produced using this method could not very far off.

The argument made above still applies quite well to the five-year stay rate estimates made for persons receiving doctorates in 2000. The proportion of academic-year 2000 foreign national doctorate recipients missing Social Security numbers was only 6.5 percent for temporary residents and 7.2 percent for permanent residents. (Table A-1.) However, the proportion missing Social Security numbers roughly

doubled by 2003: 13.2 percent for temporary residents and 13.9 percent for permanent residents. This created a dilemma.

On the one hand it is highly desirable to maintain consistency with earlier studies. This report compares stay rates in 2005 with earlier estimates from earlier studies. Such a comparison is suspect if the methods used to adjust raw data are changed. On the other hand, it can be argued that the assumptions underlying the previous method used to adjust for missing Social Security numbers are no longer valid. Data from the Class of 2004 indicate that U.S. citizens and foreign citizens fail to report a Social Security number at similar rates. Further, the rate is now high enough that alternative adjustment methods do make a significant difference in the estimated stay rates.

If we continued to use the previous adjustment method, we would be assuming that large numbers of foreign national doctorate recipients are leaving the country – based solely on their failure to supply a Social Security number. Would this be reasonable? To decide, data on stay rates are disaggregated by the stated intentions of doctorate recipients regarding their post-graduation plans.

Table A-2. Proportion of Non-U.S. Doctorate Recipients Without Social Security Numbers in the Doctorate Record File, by Post-Graduation Plans and Year of Doctorate, 2002 and 2004

Year of Doctorate	Plan to Stay in the United States	Plan to Leave the United States	Non-Response on Plans After Graduation
2004	11.8%	13.8%	56.9%
2002	6.9%	8.7%	31.4%

Note: Respondents with firm plans to stay (leave) are combined with those who merely intend to stay (leave) but did not yet have firm plans at the time of completing the Survey or Earned Doctorates.

The data in Table A-2 indicate that the proportion of foreign doctorate recipients failing to provide Social Security numbers increased from 2002 to 2004. Also, those who indicated that they planned to stay in the United States after graduation experienced an increase in missing Social Security numbers that was similar to the increase experienced by those who indicated they planned to leave the United States after graduation. The somewhat lower proportion missing Social Security numbers among those planning to stay in the United States does suggest that leaving may be more common among those without Social Security numbers. However, the data also suggest that something else, such as an increased desire for privacy, is causing the proportion without Social Security numbers to increase, since the big increase from 2002 to 2004 was not related to plans to stay in the United States.

In light of the above, it was decided to modify the adjustments previously made for missing Social Security numbers, but to do so in a way that would not have had an appreciable effect on previous stay estimates if the new method had been applied in earlier years. The way this is done is to treat the first 6 percentage points of missing Social Security numbers as was done in the past and explained above. This amounts to assuming that those without Social Security numbers stayed at only half the rate of similar doctorate recipients who supplied Social Security numbers. However, to the extent that the proportion missing social security numbers exceeded 6 percent, a different assumption is made. It is assumed instead that those without Social Security numbers stayed in the United States at 90 percent of the rate observed by similar doctorate recipients who supplied Social Security numbers.

The two-year stay rate estimate for 2003 doctorate recipients in 2005 was reported to be 66 percent in Table 1 of this report. Had no adjustment been made to account for the presumed lower stay rate of those missing Social Security numbers, the estimate would have been 69 percent. If it were assumed that the stay rate for those missing Social Security numbers had been only half the stay rate of those with Social Security numbers, this stay rate would have been only 65 percent.

The five-year stay rate estimate for 2000 doctorate recipients in 2005 was reported to be 68 percent in Table 3 of this report. In this case the proportion missing Social Security numbers was still relatively small, and it was assumed that those missing Social Security numbers, stayed at only half the rate of those with Social Security numbers. Had no adjustment been made to account for the presumed lower stay rate of those missing Social Security numbers the estimate would have been 70 percent. If it were assumed that the stay rate for those missing Social Security numbers all left the United States, this stay rate would have been only 65 percent.

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 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. As a result, NSF will no longer request doctorate recipients' full SSN, starting with those receiving doctorates in 2008.

After adjustment for missing Social Security numbers, 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 2005. 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 2003 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 2000 graduates residing in the United States in 2005: 2.9 percent of them are estimated to have had earnings below the threshold. Similar sets of estimates were constructed for the 1995 graduates residing in the United States in 2005: 3.0 percent of them are estimated to have had earnings below the threshold.

Effect of the Adjustments

The adjustments for missing and invalid Social Security numbers had the effect of lowering stay rate estimates slightly. The adjustments for death and for persons residing in the United States without earning as much as \$5,000 in taxable income had the effect of increasing stay rates slightly. The net effect of all adjustments on the overall stay rate was very small. The 2005 stay rates for all doctorate recipients shown in tables 4, 5, and 6 were compared with that stay rate which would have resulted if no adjustments had been made. In each case the difference, less than 1 percentage point, was not noticeable as stay rates are rounded to the nearest percentage in this report.

The most significant impact of adjustments occurs in the five-year estimate of stay rates for categories which have a high proportion of doctorate recipients missing Social Security numbers. Table 7 disaggregates an aggregate five-year stay rate of 65 percent into nearly 40 estimates of stay rates for individual countries or groups of countries. For most of these, the net effect of all adjustments is to change the stay rate by 2 percentage points or less. However, for a few of the countries with relatively small numbers of doctorate recipients, the impact was larger. The most extreme cases were New Zealand where the effect of adjustments was to lower the stay rate estimate by 6 percentage points, and Saudi Arabia where adjustments lowered the stay rate by 4 percentage points. These countries had few doctorate recipients but had several without Social Security numbers, so their percentage without Social Security numbers was unusually high. This was the primary reason why the effect of adjustments was so large in these cases.

There is an estimate following Table 4 which addresses the issue of 1995 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 2005. Unadjusted data were used to estimate that the 2005 stay rate (62 percent) “would be 21 percent higher if the rate were to represent the proportion who had worked in the United States for at least one year during the 1996 to 2005 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 paragraphs, at least for large groupings of doctorate recipients, 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 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.

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