Stay Rates of Foreign Doctorate Recipients from U.S. Universities, 2007

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Executive Summary

The United States appears to be at a stage when public funding of research and development is increasing significantly. The foreign born make up about 40 percent of the science and engineering work force with doctorates. [National Science Board, 2008] Our ability to continue to attract and keep foreign scientists and engineers is thus critical to our plans for increased investment in science and technology. However, there have been reports suggesting that increasing numbers of foreign-born scientists and engineers may be returning to their native countries.

Has the stay rate of foreign S/E doctorates begun to decline? The study described in this report has produced data that can answer this question – with one important caveat. The report covers only foreign science and engineering doctorate recipients from U.S. universities, not those with doctorates received before coming to the United States.

One complication confronting anyone who asks whether the stay rate is declining is that there may be a different stay rate for every cohort. This study has estimated stay rates in 2007 for persons receiving a doctorate one, two, five, and ten years previously; thus there are four observed stay rates. The one-year and two-year stay rates have the virtue of describing the behavior of the most recent cohorts. However, if people work here for several years before leaving one would definitely need the five-year and ten-year stay rates to observe this. See data below for the four stay rates as observed in 2007. Each gives the percentage of the relevant cohort of foreign doctorate recipients on temporary visas at the time of graduation who were estimated to be in the United States in 2007.

Stay Rates of Temporary Resident Doctorate Recipients in 2007

One-year stay rate (2006 grads)	73%
Two-year stay rate (2005 grads)	67%
Five-year stay rate (2002 grads)	62%
Ten-year stay rate (1997 grads)	60%

If all four of these stay rates moved in the same direction it would be easy to say whether the stay rate of foreign S/E doctorates is increasing, decreasing or unchanged. However, this is not always the case. It appears that a negative event like a recession or a terrorist attack does affect the stay rate, and does so primarily by affecting those cohorts graduating and seeking jobs around the time of the negative event. The cohorts receiving doctorates around 2002-2003 graduated at a time when a recession weakened demand for doctorate scientists and engineers. Also security restrictions were imposed after the 9/11 attacks which made staying in the United States more difficult and perhaps less attractive as well. A study conducted by the author two years ago documented a decline in the two-year stay rate for the cohort graduating in 2003 compared with earlier cohorts. There were signs that this was probably a temporary phenomenon, but it was impossible to be sure.

The present study finds the two-year stay rate has recovered but now the 5-year stay rate is lower than it was when observed earlier. It seems this is the same phenomenon, as the 5-year stay rate describes the behavior of the cohort that graduated in 2002. We know this decline is not simply the result of doctorates returning home after gaining valuable work experience the United States, because the ten-year stay rate has not declined but has reached a new high.

In short, this study measured four stay rates (1, 2, 3, and 10-year) in 2007 and found that only one of these had declined. One way to summarize this is to compare the 2007 stay rate with the rates averaged during the previous 6 year period. The four stay-rates observed in 2007, are on average, at 105 percent of the levels averaged during the previous 6 years. So, stay rates are five percent higher than they were during this reference period.

Stay Rates of Temporary Resident Doctorate Recipients in 2007 as a Percentage of Average Stay Rates During 2000 to 2005

One-year stay rate	106%
Two-year stay rate	101%
Five-year stay rate	100%
Ten-year stay rate	113%
Average, all four stay rates	105%

Those seeking to make the case that stay rates have declined might suggest that we should not use a six-year average, but rather compare 2007 stay rates with the year in which they previously peaked. However, the 10-year rate reached its highest ever level in 2007 and the other rates peaked in different years between 2001 and 2005, so there is no single year when stay rates peaked. However, it is possible to compare the 2007 level with the peak level for each of the four stay rates, regardless of when that peak occurred. The five-year stay rate declined to 91 percent of the peak level in 2007, but the 10-year stay rate is at 109 percent of the previous high, while the other two stay rates measured are very close to the previous peak. The average of these four is at 100 percent of the peak observed level. Stay rates have not increased much in recent years but they have never been higher.

Stay Rates of Temporary Resident Doctorate Recipients in 2007 as a Percentage of Peak Stay Rates During 2000 to 2005

One-year stay rate	101%
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Average, all four stay rates	100%

In addition to addressing the changes in stay rates over time the study also finds that:

- Doctorate recipients from the most highly rated graduate programs have lower stay rates compared to doctorate recipients from less highly ranked programs.
- Doctorate recipients from a few disciplines, agricultural sciences, economics, and other social sciences, have substantially lower stay rates than do those in other science and engineering disciplines.
- Stay rates vary greatly depending on country of citizenship and these differences have persisted for a long time. A few countries have stay rates that are well above average: China, India, Iran, Romania, Russia, Ukraine, and Yugoslavia.
- The doctorate recipients from the high stay rate countries are not distributed evenly across all doctoral programs or disciplines. In fact, this uneven distribution seems to explain most of the observed variation in stay rates across disciplines and even between highly-rated and all other doctoral programs.

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 $5,500 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 $5,500. 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 2005 foreign doctorate recipients in 2006 and 2007. 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 2007 stay rate for S/E doctorates is quite high at 69 percent overall. In comparison, the 2007 stay rates in the agricultural and social sciences are lower, around 50 percent. The highest stay rate was recorded in the computer/EE (electrical/electronic) engineering, 77 percent in 2007.

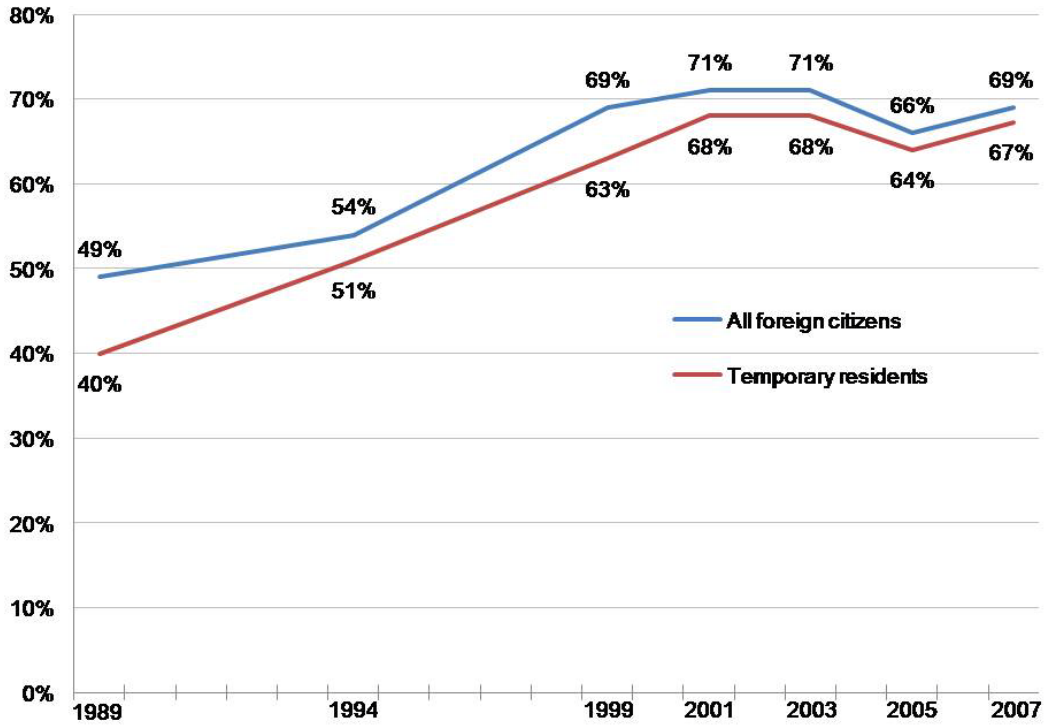
Table 1. Percentage of Foreign Students Receiving S/E Doctorates in 2005 Who Were in the United States, 2006-2007
(includes students on temporary and permanent visas)

Degree Field	Foreign Doctorate Recipients	Percent in the United States	
		2006	2007
Physical science	1,886	78	75
Mathematics	637	75	73
Computer science	638	77	75
Agricultural science	423	57	53
Life science	2,304	76	74
Computer/EE engineering	1,217	78	77
Other engineering	2,667	73	69
Economics	765	45	45
Other social science	946	55	53
Total, all fields	**11,483**	**71**	**69**

Source: Oak Ridge Associated Universities.

Figure 1 indicates that the stay rate shown in Table 1 represents a rebound after a decline experienced earlier in the decade. After increasing from 49 percent in 1989 to 71 percent in 2001 and 2003, the two-year stay rate declined to 66 percent and is now up to 69 percent.

Figure 1. Percentage of Foreign Students Receiving S/E Doctorates Who Were in the United States Two Years After Graduation, 1989-2007



Source: Oak Ridge Associated Universities.

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 2007, doctorate awards to foreign citizens have increased dramatically, by 43 percent.

Table 2. Science and Engineering Doctorates Awarded by U.S. Universities, by Citizenship Status, Selected Years, 1987-2007

Citizenship Status	1987	1992	1997	1999	2001	2003	2005	2007
Temporary visa	4,468	8,092	7,507	7,238	7,943	8,382	9,990	11,959
Permanent visa	1,089	1,383	2,281	1,654	1,270	1,098	1,112	1,222
Total, foreign citizens	**5,557**	**9,475**	**9,788**	**8,892**	**9,213**	**9,480**	**11,518**	**13,548**
U.S. citizens	**12,966**	**14,559**	**16,112**	**15,915**	**15,049**	**14,635**	**14,912**	**16,022**

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. Also, unpublished data from NSF for 2007.

Table 3 shows that the five-year stay rate for foreign students receiving doctorates in 2002 was 65 percent. Note, however, that the stay rate for this class in 2004, two years after their graduation, was 69 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 2002 Who Were in the United States, 2003-2007
(includes students on temporary and permanent visas)

Degree Field	Foreign Doctorate Recipients	Percent in the United States				
		2003	2004	2005	2006	2007
Physical science	1,506	79	77	75	73	72
Mathematics	462	73	71	68	65	65
Computer science	404	80	79	77	75	77
Agricultural science	456	56	54	49	48	48
Life science	1,972	77	74	73	71	72
Computer/EE engineering	871	80	77	75	74	73
Other engineering	2,009	70	66	64	62	62
Economics	576	50	50	49	48	47
Other social science	829	55	54	52	52	50
Total, all fields	**9,085**	**71**	**69**	**67**	**65**	**65**

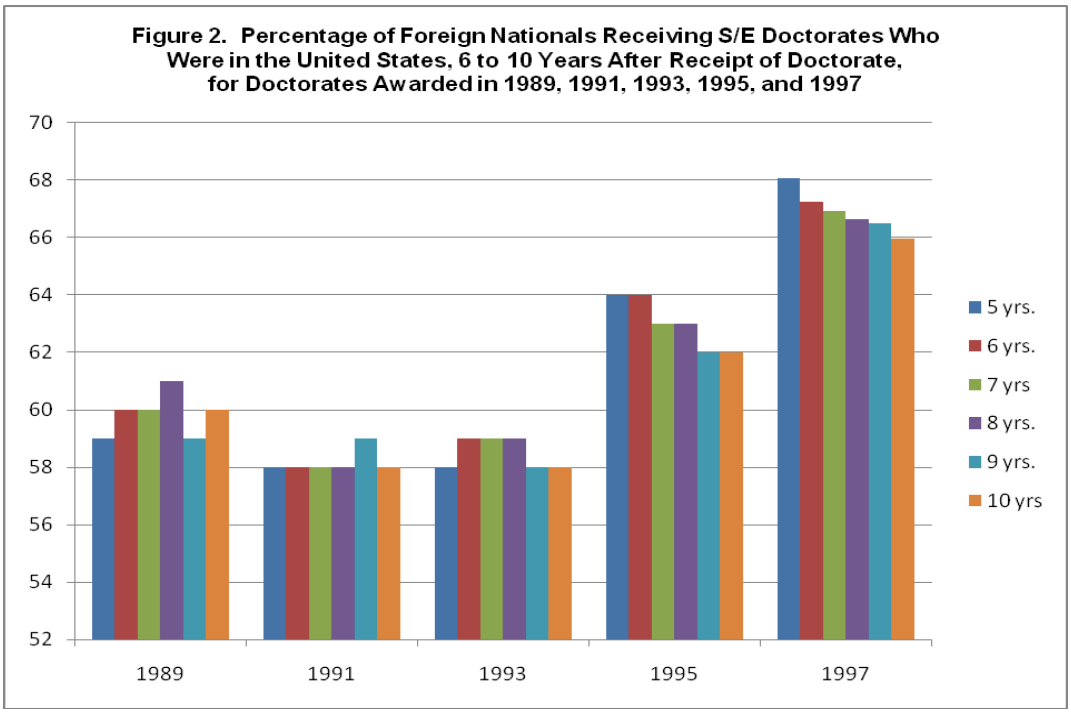
Source: Oak Ridge Associated Universities.

Table 3 also shows stay rates by degree field. The field differences are similar to the field differences shown for the 2005 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 Figure 2 indicate that this is true during the period five to ten years after graduation as well. The 2007 stay rate for all S/E doctorates awarded by U.S. universities to foreign citizens in 1997, 66 percent, is in the same range as stay rates of more recent classes in 2007. This 10-year stay rate for the class of 1997 did decline slightly during the last six years of period examined. Still, two-thirds stayed in the United States after 10 years. This provides additional evidence about how stay rates increased over the past two decades. 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.

[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.



Source: Oak Ridge Associated Universities.

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 4 shows the two-year stay rate for students on temporary visas who received doctorates in 2005. The overall stay rate shown for all S/E degree fields in Table 4 is 67 percent in 2007. This is only slightly less than the 69 percent stay rate for all foreign citizens during the same period shown in Table 1. Table 5 shows the five-year stay rate for students on temporary visas when they received their doctorates in 2002.

Table 4. Percentage of Temporary Residents Receiving S/E Doctorates in 2005 Who Were in the United States, 2006-2007

Degree Field	Foreign Doctorate Recipients	Percent in the United States	
		2006	2007
Physical science	1,731	77	73
Mathematics	575	73	71
Computer science	570	75	74
Agricultural science	393	55	51
Life science	1,973	76	73
Computer/EE engineering	1,118	77	76
Other engineering	2,482	72	68
Economics	711	43	42
Other social science	752	49	47
Total, all fields	**10,305**	**70**	**67**

Source: Oak Ridge Associated Universities.

Table 5. Percentage of Temporary Residents Receiving S/E Doctorates in 2002 Who Were in the United States, 2003-2007
(includes students on temporary and permanent visas)

Degree Field	Foreign Doctorate Recipients	Percent in the United States				
		2003	2004	2005	2006	2007
Physical science	1,309	78	76	73	71	70
Mathematics	431	73	70	67	64	63
Computer science	340	78	77	75	73	75
Agricultural science	424	54	52	47	46	46
Life science	1,588	75	72	70	68	68
Computer/EE engineering	787	78	75	73	72	72
Other engineering	1,820	68	64	62	60	59
Economics	521	48	48	46	45	43
Other social science	630	47	45	43	41	40
Total, all fields	**7,850**	**69**	**66**	**64**	**62**	**62**

Source: Oak Ridge Associated Universities.

Stay rates vary considerably by country of origin, which is shown in Table 6. Table 6 is restricted to persons on temporary visas at the time the doctorate is received. This is why the total five-year stay rate is only 62 percent in Table 6 as opposed to 65 percent in Table 3. Table 6 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 5-year stay rate for Chinese doctorate recipients, 92 percent, is the highest observed for any country in 2007. The stay rate for India in 2007, 81 percent, is also high given that none of these were permanent residents at the time of graduation.

Table 6. Percentage of Temporary Residents Receiving S/E Doctorates in 2002 Who Were in the United States, 2003-2007

Country of Origin	Doctorate Recipients	Percent in the United States				
		2003	2004	2005	2006	2007
China	2,139	94	93	92	92	92
Taiwan	451	58	51	47	44	43
Japan	144	44	38	36	32	33
South Korea	814	61	53	47	44	41
India	615	91	89	85	83	81
Thailand	312	10	10	9	8	7
Other East Asia	113	52	49	48	46	47
Iran	36	90	82	85	76	79
Israel	26	69	69	65	57	57
Saudi Arabia	71	6	6	6	7	7
Turkey	315	53	49	46	44	42
Other West Asia	230	65	64	64	63	64
Australia	27	71	67	49	54	45
Indonesia	61	44	33	27	26	29
New Zealand & other Pacific/Australasia	21	49	33	28	28	28
Egypt	88	55	44	46	45	46
South Africa	23	50	45	45	45	45
Other Africa	146	63	61	57	55	55
Greece	68	66	61	58	51	51
United Kingdom	89	68	65	64	68	64
Germany	164	58	58	54	51	52
Italy	107	60	62	61	61	63
France	83	54	50	50	49	45
Romania	121	88	88	89	87	86
Spain	50	55	51	55	49	45
Other EU countries	262	61	60	61	59	56
Russia	161	83	85	82	80	77
Yugoslavia	32	87	87	88	88	88
Ukraine	49	83	85	86	81	84
Other Europe	102	75	72	67	62	61
Canada	258	65	64	58	52	55
Mexico	173	36	34	28	28	32
Argentina	54	67	58	58	59	54
Brazil	119	32	34	32	30	31
Chile	40	17	19	22	22	22
Colombia	49	52	52	52	46	48
Peru	28	71	67	64	60	57
Venezuela	49	37	39	39	43	50
Other Central/So. America	94	44	44	43	40	43
Country not reported	66	59	59	60	40	40
Total, all countries	**7,850**	**69**	**66**	**64**	**62**	**62**

Source: Oak Ridge Associated Universities.

Not all of the large source countries for foreign students display high stay rates in Table 6. Taiwan's stay rate was only 43 percent in 2007, and South Korea's was only 41 percent. Other countries with even lower low stay rates include Thailand and Saudi Arabia (7 percent), Chile (22 percent), New Zealand (28 percent), and Indonesia (29 percent). Countries with above average rates in 2007 include Iran (79 percent), Romania (86 percent), Yugoslavia (88 percent), Ukraine (84 percent), and Russia (77 percent).

The country-by-country variation in stay rates shown in Table 6 is similar to the patterns observed in previous years. Table 7 shows such a comparison for selected countries. For each of the classes examined in Table 7, 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 seven time periods examined. The overall pattern is one of stability in term of country rankings. One could predict current stay rates for each country reasonably well simply by knowing what the country-specific stay rate had been in the past.

Table 7. 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, 1992-2007

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	2002 Doctorate Recipients in 2007
China	65	88	92	91	96	90	92	92
India	72	79	83	87	86	86	85	81
United Kingdom	na	59	56	60	53	60	58	64
Canada	32	46	48	55	62	58	56	55
Greece	44	41	46	49	53	60	54	51
Germany	na	35	38	53	48	51	49	52
Taiwan	47	42	36	42	40	47	50	43
Japan	17	13	21	27	24	37	39	33
Brazil	13	25	15	21	25	25	30	31
Korea	17	11	9	15	21	34	42	41
Average, all countries	41	47	53	51	56	61	65	62

Source: Oak Ridge Associated Universities.

Have Stay Rates Declined?

One complication confronting anyone who asks whether the stay rate is declining is that there may be a different stay rate for every cohort. This study presents estimated stay rates in 2007 for persons receiving a doctorate one, two, five, and ten years previously; thus there are four observed stay rates. The one-year and two-year stay rates have the virtue of describing the behavior of the most recent cohorts. However, if people work here for several years before leaving one would definitely need the five-year and ten-year stay rates to observe this. Table 8 shows the four stay rates as observed in 2007. Each gives the percentage of the relevant cohort of foreign doctorate recipients on temporary visas at the time of graduation who were estimated to be in the United States in 2007.

Table 8. Stay Rates of Temporary Resident Doctorate Recipients in 2007

One-year stay rate (2006 grads)	73%
Two-year stay rate (2005 grads)	67%
Five-year stay rate (2002 grads)	62%
Ten-year stay rate (1997 grads)	60%

Source: Oak Ridge Associated Universities.

If all four of these stay rates moved in the same direction it would be easy to say whether the stay rate of foreign S/E doctorates is increasing, decreasing or unchanged. However, this is not always the case. It appears that a negative event like a recession or a terrorist attack does affect the stay rate, and does so primarily by affecting those cohorts graduating and seeking jobs around the time of the negative event. The cohorts receiving doctorates around 2002-2003 graduated at a time when a recession weakened demand for doctorate scientists and engineers, and also security restrictions were imposed after the 9/11 attacks which made staying in the United States more difficult and perhaps less attractive as well. A study conducted by the author two years ago documented a decline in the two-year stay rate for the cohort graduating in 2003 compared with earlier cohorts. There were signs that this was probably a temporary phenomenon, but it was impossible to be sure.

The present study finds the two-year stay rate has recovered but now the 5-year stay rate is lower than it was when observed earlier. It seems this is the same phenomenon, as the 5-year stay rate describes the behavior of the cohort that graduated in 2002. We know this decline is not simply the result of doctorates returning home after gaining valuable work experience the United States, because the ten-year stay rate has not declined but has reached a new high.

In short, this study measured the four stay rates (1, 2, 3, and 10-year) in 2007 and found that only one of these had declined. One way to summarize this is shown in Table 9. It compares the 2007 stay rate with the rates averaged during the previous 6 year period. The four stay rates observed in 2007, are on average, at 105 percent of the levels averaged during the previous 6 years. So, stay rates are five percent higher than they were during this reference period.

Table 9. Stay Rates of Temporary Resident Doctorate Recipients in 2007 as a Percentage of Average Stay Rates During 2000 to 2005

One-year stay rate	106%
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Ten-year stay rate	113%
Average, all four stay rates	105%

Source: Oak Ridge Associated Universities.

Those seeking to make the case that stay rates have declined might suggest that we should not use a six-year average, but rather compare 2007 stay rates with the year in which they previously peaked. However, the 10-year rate reached its highest ever level in 2007 and the other rates peaked in different years between 2001 and 2005, so there is no single year when stay rates peaked. However, it is possible to compare the 2007 level with the peak level for each of the four stay rates, regardless of when that peak occurred. Table 10. This table shows that the five-year stay rate declined to 91 percent of the peak level in 2007, but that the 10-year stay rate is at 109 percent of the previous high, while the other two stay rates measured are very close to the previous peak. The average of these four is at 100 percent of the peak observed level. Stay rates have not increased much in recent years but they have never been higher.

Table 10. Stay Rates of Temporary Resident Doctorate Recipients in 2007 as a Percentage of Peak Stay Rates During 2000 to 2005

One-year stay rate	101%
Two-year stay rate	99%
Five-year stay rate	91%
Ten-year stay rate	109%
Average, all four stay rates	100%

Source: Oak Ridge Associated Universities.

Quality Measures and Stay Rates

It would be of interest to know whether the roughly one-third who leave the United States are, by any reasonable measure, better or worse scientists and engineers than the roughly two-thirds who stay. There is some limited evidence on this issue from a past study. Finn, Pennington and Anderson (1995) examined the earnings of doctorate recipients who worked in the United States for a while after graduation but then left. They found no significant difference in earnings between those who left and comparable doctorate recipients who stayed on in the United States. Insofar as earnings reflect labor market success the leavers appeared to be similar to the stayers.

In this section we examine another proxy for the quality of scientists and engineers: the ranking of the academic programs from which they obtained their doctorates. To do this we relied primarily on the rankings of the National Research Council and U.S. News and World Report magazine, each of which uses a survey to measure the research reputations of the faculty staffing these academic programs. For each of the nine degree fields used in earlier tables in this report, 20 to 25 top-rated departments were identified. Then the stay rates were computed for each of these 9 discipline groupings, separately for those in top-rated programs, and those in all other programs. The results vary somewhat by discipline group, but these discipline groups were combined to produce the weighted averages seen in Table 11. See Appendix for more detail on the method and lists of the schools that were top-rated for each of nine separate discipline groups.

Table 11. Percentage of Temporary Residents Receiving Doctorates in 2002 Who Were in the United States, by Program Quality Ranking, 2003 to 2007

		Percent in the United States				
Program Quality Category	Doctorate Recipients	2003	2004	2005	2006	2007
Top-rated programs	2,611	67	63	61	59	58
All other programs	5,239	70	68	65	64	63
Total, all programs	7,850	69	66	64	62	62

Source: Oak Ridge Associated Universities.

Table 11 indicates that the 5-year stay rate for those from the top-rated departments was only 58 percent, compared with 63 percent for those from all other departments. At first glance this outcome is puzzling. While there must be many factors affecting the decision to stay, the ability to obtain an attractive job in the United States is one of those factors. Surely, graduating from a top-rated department is at least some modest help in this regard. Thus, one might have expected the opposite – that the doctorate recipients from the top-rated departments would have slightly higher stay rates than other doctorates.

A recent paper "Internationalization of the U.S. Doctorate" (Bound, Turner and Walsh, 2009) points to a possible explanation of the results in Table 11. The paper posits that "students from countries with relatively substantial university systems will be unlikely to study in the U.S. unless they can attend top-tier doctorate programs" and examines data on students at "Top-five" programs in four S/E disciplines. They found empirical support for their hypothesis. A substantially smaller percentage of graduate students from China and India were found in these top programs, compared with students from higher income countries in Europe, Japan and Canada. This suggests an explanation for the lower stay rates for top-rated programs shown in Table 11—the top-rated doctoral programs may have relatively fewer graduates from countries with the highest stay rates.

Table 12 shows the distribution of temporary resident doctorate recipients in 2002 by country group for top-rated programs and other programs. Countries of citizenship for these doctorate recipients are aggregated into the following groups: countries with stay rates above 75 percent, countries with stay rates below 45 percent, and all others. The top-rated programs as a group have awarded only 35.8 percent of their S/E doctorates to students from countries with stay rates above 75 percent, while all other programs awarded 42.8 percent of their S/E doctorates to students from these high stay rate countries. Also, a greater percentage of doctorate recipients from the top-rated programs were citizens of countries with the low stay rates, below 45 percent. These differences in country of citizenship of the foreign doctorate recipients can explain most of the difference in stay rates between the group of top-rated programs and all other programs. There are no countries for which the estimated stay rate is between 65 and 75 percent. However, there are seven countries with stay rates over 75 percent: China (92 percent), Romania (86 percent), Yugoslavia (88 percent), Ukraine (84 percent), India (81 percent), Iran (79 percent), and Russia (77 percent). Programs which admit above average proportions of foreign students from these countries are likely to have graduates with above average stay rates.

Table 12. Doctorate Recipients with Temporary Visas by Doctoral Program Quality Group and Country of Citizenship Group, 2007

				Country of Citizenship Stay Rate Group					
		Total Reporting Country of Citizenship		Above 75 Percent		Below 45 Percent		All Other Countries	
Doctorate Recipient Group	Total in Group	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Top-rated programs	2,611	2,567	97.7	920	35.8	911	35.5	736	28.7
All other programs	5,239	5,218	99.9	2,233	42.8	1,607	30.8	1,378	26.4
Total	7,850	7,785	99.2	3,153	40.5	2,518	32.3	2,114	27.2

Source: Oak Ridge Associated Universities.

Country of Citizenship Explains a Lot

Differences in country of origin provides a plausible explanation of the reason why stay rates are lower for top-rated departments. Country of origin can explain other differences in stay rates as well. Tables 4 and 5 documented substantial differences in stay rates by discipline. In this report, and in all previous reports by the author, a few academic disciplines (or discipline groups) have below average stay rates: agricultural sciences, economics, and other social sciences. If we examine country of origin by discipline a plausible explanation can be found. See Table 13. It appears that country of citizenship can explain

most differences in stay rates and that the large differences in stay rates by discipline reflect large differences in the country of origin among disciplines.

Table 13. Correlation Between the 2007 Five-Year Stay Rate by Discipline, and the Percentage of Each Discipline's Foreign Graduates with Citizenship in One of the Five Countries with the Highest Stay Rates in 2007

Degree Field	Stay Rate	Percent from the Five Highest Stay Rate Countries
Computer science	72	44
Computer/EE engineering	69	50
Physical science	68	49
Life science	67	45
Mathematics	62	43
Other engineering	58	43
Agricultural science	45	24
Economics	42	20
Other social science	39	17
Correlation coefficient:		0.96

Note: The five countries with the highest five-year stay rates in 2007 were China, India, Romania, Yugoslavia, and Ukraine.

Source: Oak Ridge Associated Universities.

Migration vs. Circulation

The stay rate discussion above has focused primarily on the most recent year for which we have data available, 2007. The 5-year stay rate in 2007 is the percentage of the 2002 graduates estimated to be in the United States in 2007. However, it is incorrect to assume that all migration is one-way and that the migrants stay continuously. Some foreign doctorate recipients work in the United States for a while after graduation, leave for work abroad, only to return at a later date. Others leave immediately upon graduation but may be back in the United States after five or ten years. One can get some measure of just how much of this movement occurs by asking how much lower would the 5-year stay rate have been in 2007 if it had been calculated by excluding persons who had less than $5,500 in U.S. earnings in at least one of the years between 2003 to 2006, i.e., if it required continuous residence in the United States. The answer is that it would have been 9 percent lower. The estimated 5-year stay rate was 62 percent, so this means that at least 5 percent (0.09 x 0.62) of the 2002 doctorate recipients left the United States for a year or more but later returned to be here during 2007 and to make up part of the 62 percent who were here at that point.

Table 14 presents data showing how this measure of the circulation of S/E doctorates varies by country and region. Overall 9 percent of the 2002 graduates who were here in 2007 were outside the United States for at least one of the years between 2002 and 2007. However, citizens of countries in the Western Hemisphere were much more likely to circulate in this fashion—21 percent vs. 9 percent. Interestingly, there was even more of this circulation among those from countries to the south of the United States than among those from Canada.

Table 14. Percent of Temporary Recipients who Left for at Least One Year, but were in the United States Five Years After Receiving S/E Doctorate in 2002, by Region and Selected Countries

		5-Year Stay Rate in 2007	Percent of Stayers Who Were Not in the U.S. at Least One Year During 2003-2006
Western Hemisphere	864	44	21
Canada	258	55	17
Other Central/South America	173	32	24
Outside Western Hemisphere	6,920	64	8
High State Rate Countries	2,956	89	6
High Income Countries	2,044	45	12
All Other Countries	1,920	42	9
Total, All Countries	7,784	62	9

Notes: "High Income Countries" include only Australia, France, Japan, Israel, Italy, Greece, Germany, New Zealand, South Korea, Spain, and the United Kingdom. Other high income countries accounted for small numbers of doctorate recipients, were not estimated separately, and are included in the grouping "All Other Countries."

"High Stay Rate Countries" include China, India, Iran, Romania, Russia, Ukraine, and Yugoslavia.

Source: Oak Ridge Associated Universities.

The countries outside the Western Hemisphere are divided into three groupings in Table 14. One is a group of "High Stay Rate" countries. These are seven countries all with a stay rate greater than 75 percent. The group is dominated by China and to a lesser extent India, and accounts for nearly half of all stayers. This group of countries has the lowest percentage spending at least a year outside the United States. Compared with the citizens of other countries doctorate recipients in this group tend to stay at a much higher rate and to stay more continuously.

A group of High Income countries outside the Western Hemisphere is also shown separately. These countries tend to have well established research universities as well as extensive R&D employment outside universities, and these jobs typically pay attractive salaries. Thus, one might expect to see considerable circulation back and forth between these countries and the United States. Table 13 documents that these countries do have above average circulation: it is twice as much as in the High Stay Rate countries. However, at 12 percent, the percentage is still lower than the 21 percent observed for countries in the Western Hemisphere.

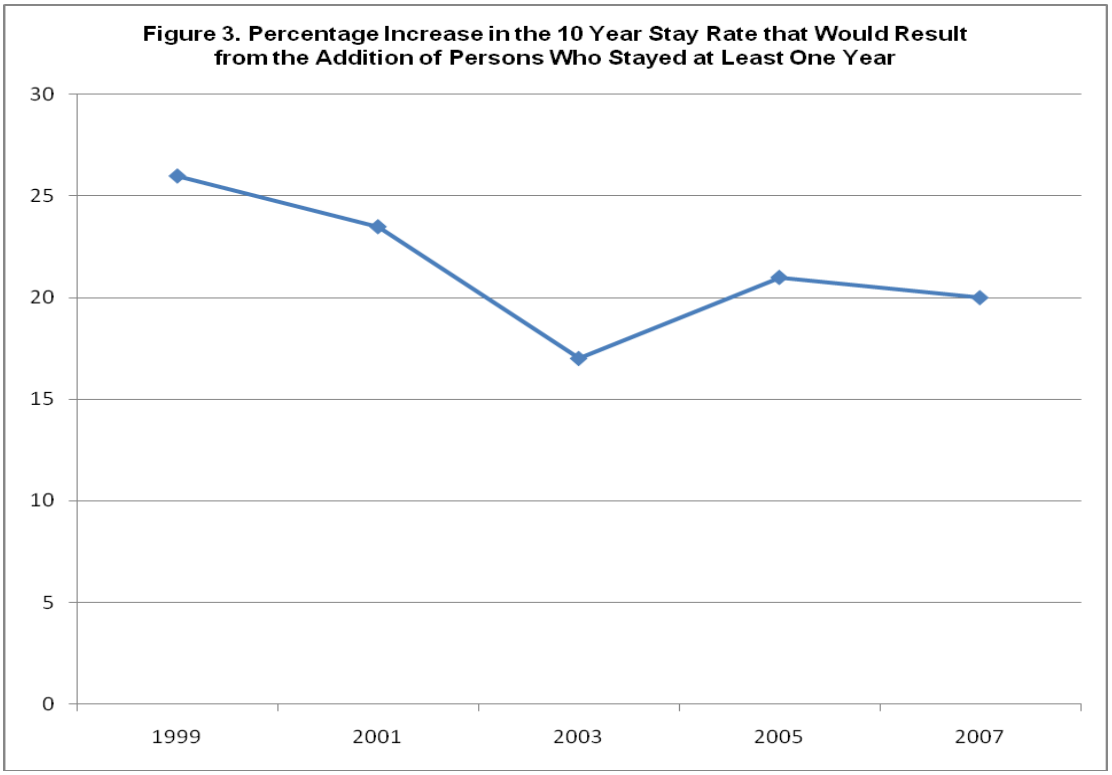
The data in Table 14 refer to the 5-year stay rate. Data on the ten-year stay rate can also be used to illuminate the circulation of early-career S/E doctorate recipients. The ten-year stay rate in 2007 was 66 percent. This was reported in Figure 2 and it includes doctorate recipients who were on either temporary or permanent visas at the time of graduation. How much higher would this stay rate have been if, instead of counting only those who were still here in 2007 as stayers, we had counted those with at least five, three, or one year in the United States during the decade after they received their doctorate in 1997. The answer is that the 10-year stay rate would have been 7 percent higher if five years residence were required, 12 percent higher if 3 years residence were required and 20 percent higher if only one year residence were required to qualify as a stayer.

A person who stays only one or two years after receipt of the doctorate may be staying just to obtain the additional training and experience associated with a postdoctoral appointment. This is also true of some who stay three or four years or even five years before leaving. The widespread phenomenon of postdoctoral study surely explains a large part of the reason why, among those not here after 10 years,

the number who had spent at least a year in the United States is nearly three times as large as the number who spent at least 5 years.

Data to track whether this kind of circulation has changed over time has been developed for only one of these statistics: How much would the 10-year stay rate increase if those staying at least one year were added to those here after 10 years? These data are shown in Figure 3. While this is only one of many possible ways to track changes in the circulation of recent S/E doctorate recipients, the data in Figure 3 indicate that there has been a modest decline in this phenomenon. If there had been an increase in the percentage of recent foreign doctorate recipients who worked here for one or more years but then left the United States before the 10th year after graduation, one would expect the graph in Figure 3 to show an increase rather than the slight decrease it does show.

This may seem surprising as there have been many anecdotal reports of S/E doctorates moving back and forth between the United States and other countries. However, it is possible that the doctorate recipients from most countries are experiencing increased circulation of this sort even though the aggregate statistics shown in Figure 3 show a slight decline. One possible explanation is the change in the composition of foreign doctorate recipients by country of origin. As shown in Table 14 there is a low level of circulation during the first five years after graduation among the S/E doctorate recipients from high stay rate countries, while there is much higher than average circulation during the first five years after graduation among the countries in the Western Hemisphere. NSF degree award statistics indicate that from 1988 to 1997 doctorate recipients who were citizens of Western Hemisphere countries declined from about 11 percent to 9 percent of the total, while doctorate recipients from China and India (the two highest stay rate countries) increased from 16.5 percent to 37 percent of the total. (NSF, 1999) Thus, it is possible that there is increased circulation between the United States and every region of the world, but the trend shown in Figure 3 would result if this is offset by the huge increase in the share of doctorates awarded to two countries, China and India, that now account for more than a third of all foreign S/E doctorate recipients.



Source: Oak Ridge Associated Universities.

However, squaring these data with the anecdotal reports of increasing numbers of U.S. doctorate recipients returning to China or India is not as easy as this. Some of these reports actually focus on persons returning to India and/or China. This report is based on an analysis of all the doctorate recipients from those countries, not on anecdotes or case studies. The data shown above on circulation (leaving after working in the U.S for a while) are not the last word. Any thoughtful reader may suggest additional statistics to better measure this phenomenon. Still, these data do measure circulation and they do not suggest that it is particularly large (except in the Western Hemisphere) nor do they show evidence that circulation, in the aggregate, is increasing.

Vivek Wadhwa has been a prominent voice sounding alarm that a reverse drain brain is already taking place. He and his team interviewed R&D companies in India and China and identified several with large numbers of returnees among their R&D staffs. He concluded that return migration of scientists and engineers has been increasing dramatically in recent years, and that the demand for highly trained scientists and engineers would continue to increase. His team also used Facebook to survey an admittedly unscientific sample of foreign nationals currently studying at U.S. universities or who graduated in 2008. They found that "The largest group of respondents—55% of Indian, 40% of Chinese, and 30% of European students -- wants to return home within five years. These survey results led Wadhwa and his team to the alarming conclusion that, "The United States is in danger of losing large numbers of talented foreign-national students, particularly those from India and China." (Wadhwa, 2009)

How do the results of this report square with those reported by Wadhwa? One could argue that the two studies do not conflict. This report focuses on the behavior of persons earning doctorates in 2006 and earlier. The data presented above relevant to circulation and return migration was confined to persons who graduated in 1997 and 2002. So it is possible that circulation was modest among graduates of those years but that it will increase dramatically as more recent cohorts complete their doctoral studies and get a few years experience in the United States. However, there are several reasons to be skeptical of predictions of increased return migration based on the facts presented in the Wadhwa study. First, his respondents did not constitute a representative sample of all graduate students. But, perhaps more important, on an issue such as staying in the United States after graduation it appears that student's intentions evolve substantially as they move towards graduation. Most of these students had to convince a representative of the U.S. Department of State that they intended to return home in order to get the visa to study in the United States in the first place. It is plausible that, for most foreign students, intentions were stated truthfully at this time but that they evolve slowly towards being more disposed to stay in the United States after graduation.

If and when there is a substantial decline in 5-year stay rates, we would expect that there would be some earlier indication in the form of falling one-year or two-year stay rates and a decline in stated intentions to stay declared by new doctorate recipients. Neither of these is evident in the most recent data available. As shown in the next section, the proportion of new doctorate recipients in 2007 who indicated an intention to stay in the United States after graduation was at an all time high. As shown in Figure 1, the actual 2-year stay rate for S/E doctorates increased from 2005 to 2007, and was near the all time high in 2007. The most recent one-year stay rate is shown in the next section and it also is at an all-time high. So there is no warning in the most recent stay rate or intentions data that would point to a developing decline in the stay rates of S/E doctorates.

If Wadhwa's survey of graduate students' intentions were based on a scientific survey, and if it had been conducted repeatedly so as to produce time series data on graduate students intentions to stay in the United States after graduation then this might be taken as a potentially valuable indicator. However, to confidently extrapolate stay rate behavior from intentions stated at an earlier date one would need as well to see how well the intentions data have predicted actual behavior in the past. Of course, Wadhwa cannot do this because he only surveyed students at one point in time. However, the Survey of Earned Doctorates has collected intentions data annually for many years. In the next section we examine these data and show that they have provided a good early indication of actual stay rates. But first the data on one-year stay rates are presented as these would be the first indication in actual behavior if a trend towards a decreased stay rates is started.

Indicators of Future Stay Rates

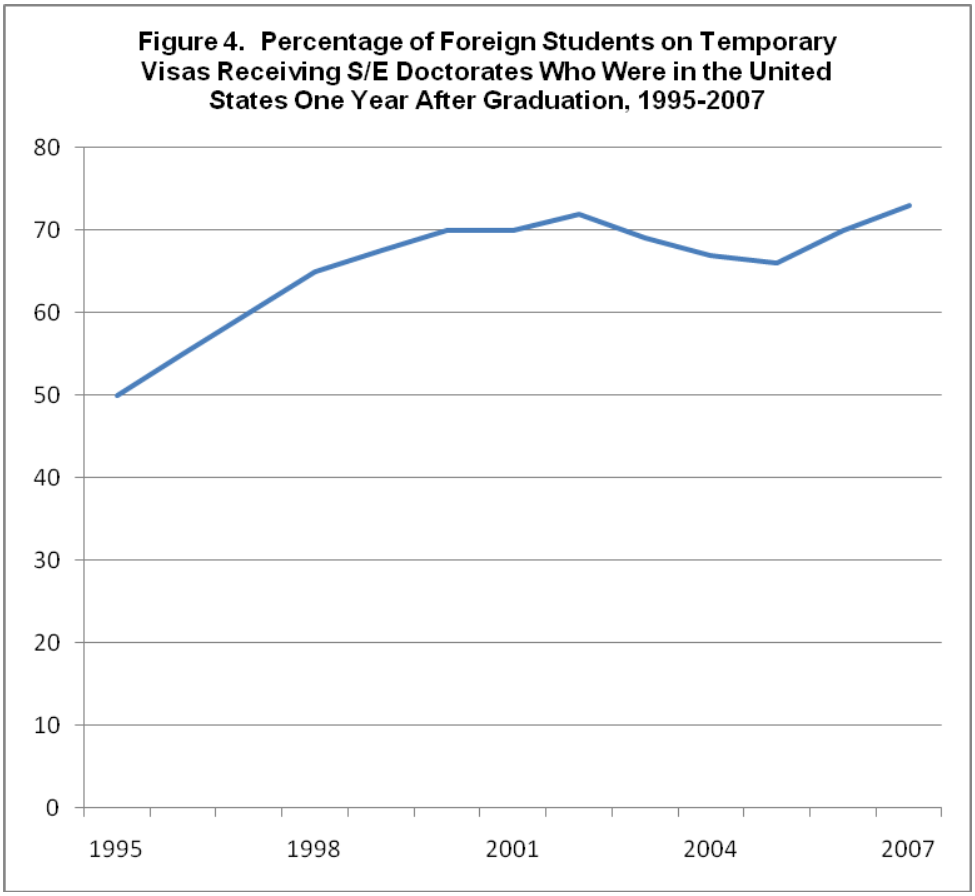
Table 15 shows the one-year stay rate for 2006 doctorate recipients and for several earlier classes. Table 15 is confined to persons who had temporary visas at the time of graduation. This table shows that the two-year stay rate leveled off and then declined between the classes of 2001 and 2003. The 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 started increasing with the class of 2004 and has reached a new high of 73 percent with the most recent class, those graduating in 2006. See Figure 4 for a graph of the one-year stay rate. This turnaround in the one-year stay rate has been followed by an increase in the 2-year stay rate as well.

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, in the years after 2003 the economy 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 recovery in one-year stay rates shown in Table 15 for the class of 2004 through 2006.

Table 15. Percentage of Foreign Students Receiving S/E Doctorates in 2006 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
2006	73	NA
2005	70	67
2004	68	NA
2003	67	64
2002	69	NA
2001	72	68
2000	70	68
1999	70	68
1997	65	63

Source: Oak Ridge Associated Universities.



Source: Oak Ridge Associated Universities.

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 have signed a contract or have a definite commitment of employment, are described as having "definite plans to stay" in Table 16. 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 16 indicate intentions to stay declined in 2003 but by 2005 had begun to turn up again. Of these two different measures of intentions to stay in the United States after graduation, the more comprehensive one has been the closest to actual observed stay rates as reported in this and earlier reports by the author. This more comprehensive "plans to stay" measure includes persons who wish to stay but have not yet secured positions at the time of the survey, so it is not surprising that it would be slightly higher than the observed 1-year stay rate. From 1997 to 2006 the intentions data (for "plans to stay") reported in Table 16 ranged from 2 to 5 percentage points higher than the actual 1-yr stay rate. For the past five years for which data are available the plans to stay variable has been in the range of 4 to 5 percentage points higher than the actual stay rate. Thus, the fact that intentions data measured by "plans to stay" has reached a new high of 79 percent in 2007 suggests that the trend for stay rates is likely to be increasing.

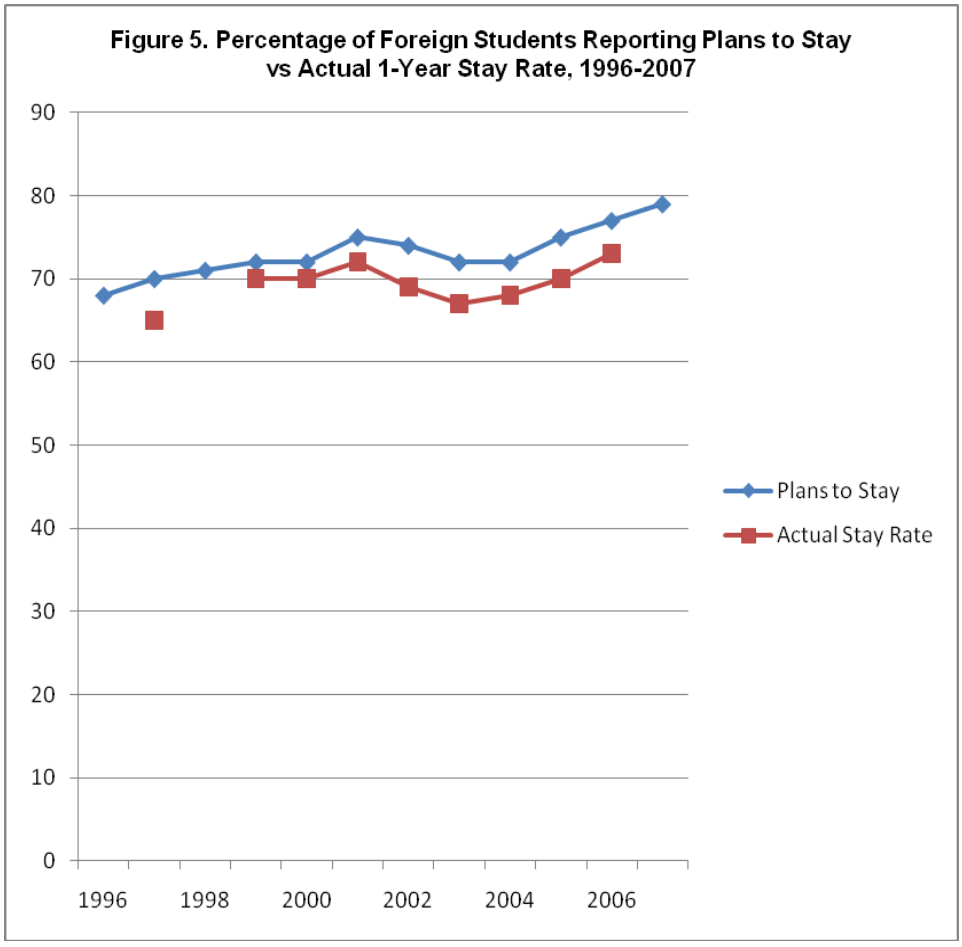
Table 16. Percentage of Foreign Doctorate Recipients Reporting Plans to Stay in the United States After Graduation, 1996-2007
(includes only students on temporary visas)

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Definite Plans to Stay	38	42	44	47	49	54	51	48	47	50	53	53
Plans to Stay	59	63	63	67	68	73	71	70	70	74	77	79

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 5 indicates how closely the actual 1-year stay rate has moved with the percentage of new doctorate recipients indicating plans to stay.



Note: Actual stay rate not computed for graduates of 1996, 1998, or 2007.

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.

Summary and Conclusions

First, stay rates continue to vary substantially by country of citizenship. Moreover, country of citizenship goes a long way towards explaining other variations in stay rates. For example, variations in stay rates by discipline appear to result largely from the fact that the students from high stay rate countries (e.g., China and India) are more heavily concentrated in some disciplines than others. Also, graduates of the top-rated academic programs have lower stay rates than all other graduates, but this too can be largely explained by the lower proportion of students from countries with high stay rates in the top-rated programs.

Second, the data for all available cohorts indicate that stay rates of foreign S/E doctorate recipients in 2007 are slightly higher than they have been in previous years. Although one of the four stay rates examined, the five-year rate, is below its earlier peak in 2007, this appears to be the result of special conditions prevailing in 2002 when this cohort graduated. The stay rates for other cohorts in 2007 are at or near new highs.

In recent years there has been a close relationship between the actual one-year stay rate and plans to stay as reported to the Survey of Earned Doctorates. This suggests that these data on intentions available from the Survey of Earned Doctorates should be reviewed by those who are interested in the future of stay rates. The plans to stay reported to the 2007 Survey of Earned Doctorates are at a new high.

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 118 groups of Ph.D. recipients who received S/E degrees from U.S. universities in 1997, 2002, 2005, and 2006.

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 2002 with a degree in computer science). The NORC staff then prepared a data file containing the birth years and Social Security numbers of the persons in each of these groups. All the persons with the traits used to define the group were included, provided that NORC had a Social Security number for them. In total, groups of foreign citizens containing a total of 77,920 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 $5,500 in earnings. For example, one group consisted of 2,139 citizens of China who were shown by the NORC to have received science or engineering doctorates from U.S. universities in 2002. Some of these were missing Social Security numbers but the remaining 2,024 were forwarded to the Social Security Administration in one group. The Social Security Administration found that six of these had Social Security numbers that were invalid, and 18 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 2,000 with presumed valid Social Security numbers. The Social Security Administration reported that 1,794 of the 2,000 individuals were recorded as having earned $5,500 or more in the United States in 2007. This can be used to calculate a stay rate of 1,794/2,000 or 89.7 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 1.9 percent of foreign citizens had birth years that did not match within one year. A failure to match birth years in 1.9 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 1.9 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 1.9 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 $5,500 or more in each year from 1998 to 2007. This produced only one group where a problem 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 $5,500 or more. The original request defined New Zealand and "Other Pacific/Australasia" as two separate groups. Since one of these groups did not meet the confidentiality criteria, the two groups were combined.

The decision to use a threshold of $5,500 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 $5,500, 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 have earned about $12,000 per year in 2007. A $5,500 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 some of the time Social Security numbers are missing because some foreign graduates did not have Social Security numbers, even though the vast majority does.

Table A-1 shows how the proportion of doctorate recipients missing valid Social Security numbers varies by year of graduation and visa status. The proportion of foreign citizens missing Social Security numbers increased dramatically from the class of 1997 to the classes of 2005 and 2006. Prior to 2006 the Survey of Earned Doctorates requested full Social Security numbers from all respondents. However, in 2006 ten percent of respondents were asked only for the last 4 digits of their Social Security numbers. This explains why the proportion without valid Social Security numbers increased dramatically in 2006. But why did the proportion missing Social Security numbers increase during the years between 1997 and 2005?

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, accompanied by an increasing reluctance of universities to use Social Security numbers for identification purposes. Indeed, this is the reason why 10 percent were not asked for a full Social Security number in 2006. NSF was preparing for 2007 and subsequent years when the Survey of Earned Doctorates refrained from asking any of the respondents for full Social Security numbers.

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

Year of Graduation	Temporary Residents	Permanent Residents
2006	24.7	n.a.
2005	14.6	19.0
2002	8.5	8.8
1997	5.0	3.3

Source: Oak Ridge Associated Universities.

There are 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. [Finn, 2008] 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.

Also, Table A-1 shows that the increase in the percentage of the doctorate recipients without valid Social Security numbers was slightly greater for foreign naturals who were permanent residents at the time of graduation than it was for those who were temporary residents at graduation. This suggests that there is something other than an intention to leave that is causing the increase in respondents without Social Security numbers.

To obtain more insight on this issue the subset of 2006 temporary residents who declared firm plans to work or stay in the United States was examined. This group is slightly more than half of the total shown in Table A-1 and they were missing Social Security numbers only 24.4 percent of the time, compared with 24.7 percent for the total of all 2006 temporary residents. Thus, in 2006 supplying a Social Security number was no more common among this subset which had a stay rate of nearly 100 percent than it was among the others who, together, had a much lower stay rate.

The increased tendency for the more recent cohorts not to provide a Social Security number is a cause for concern, however, 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.

It is necessary to assume something about the stay rate behavior of the doctorate recipients without Social Security numbers. In reports dated 2005 and earlier by the author the simple expedient of assuming that those without Social Security numbers stayed at half the rate of the others was chosen. This was done on the grounds that the real value must be between zero and one, the proportion without Social Security numbers was small, and choosing a value in the middle, 0.5, meant that the total estimate could not be off by more than one or two percentage points. But things have changed. It could now make a difference of several percentage points, depending on what is assumed about those individuals missing Social Security numbers. Also, as the proportion missing Social Security numbers rose during the first half of the present decade there was increasing evidence that the failure to supply a Social Security number was probably not associated with any higher tendency to leave the United States after graduation. Recall the evidence noted above that permanent residents and U.S. citizens were not more likely to supply a Social Security number, and among temporary residents in 2006 those with firm plans to stay were missing Social Security numbers at about the same rate as all others. For the more recent classes, those without Social Security numbers probably stayed at about the same rate as the others that supplied Social Security numbers.

However, there is a case for being conservative in making any assumption about the behavior of those without Social Security numbers. In this case, conservative means trying to make sure that the assumptions chosen cannot produce a large error. Accordingly, it was assumed that for the class of 1997 those without Social Security numbers stayed at half the rate of those who supplied valid Social Security numbers, and for those graduating in 2002, 2005 it was assumed those without Social Security numbers stayed at 80 percent of the rate of those who supplied valid Social Security numbers. For those graduating in 2006 (when ten percent were not even asked for full Social Security numbers) it was assumed that those without Social Security numbers stayed at 90 percent of the rate of those who supplied valid Social Security numbers.

The two-year stay rate estimate for 2005 doctorate recipients in 2007 was reported to be 69 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 72.5 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 63.8 percent.

The five-year stay rate estimate for 2002 doctorate recipients in 2007 was reported to be 65 percent in Table 3 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 65.9 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 63.1 percent.

The ten-year stay rate estimate for 1997 doctorate recipients in 2007 was reported to be 65 percent in Table 3 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 65.9 percent. If it were assumed that those missing Social Security numbers all left, this stay rate would have been 64.5 percent.

After adjustment for missing Social Security numbers, the proportion paying taxes on at least $5,500 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 $5,500 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, 1997 and 2003 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 2005 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 $5,500 (the amount was adjusted upward for inflation) even though they resided in the United States. Similar sets of estimates were constructed for the 2002 graduates residing in the United States in 2007: 2.9 percent of them are estimated to have had earnings below the threshold. Similar sets of estimates were constructed for the 1997 graduates residing in the United States in 2007: 3.0 percent of them are estimated to have had earnings below the threshold.

Effect of all 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 $5,500 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 2007 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 was 1 percentage point or less.

A more 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 6 disaggregates an aggregate five-year stay rate of 62 percent into 40 estimates of stay rates for individual countries or groups of countries. For each of these, the net effect of all adjustments is to change the stay rate by 2 percentage points or less.

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 2007 or who had earnings less than $5,500. 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.

Identification of Highly Ranked Schools

There are two distinct reasons why one might ask whether the graduates of the most highly ranked doctorate programs are more likely to stay in the United States after graduation than are others graduating from less distinguished programs. First, as foreign doctorate recipients likely provide a benefit to the United States if they stay, then it would seem that the benefit would also vary by program quality. That is, the United States is likely to benefit more if graduates from the most highly regarded programs stay at a higher rate than other graduates.

Another reason to consider doctoral program quality is to better understand why some stay and others do not. Clearly, the reasons for staying (or not) are multiple and vary among individual doctorate recipients. However, it is understood that some doctorate recipients leave after graduation because they cannot readily find an attractive job in the United States. However, graduating from a highly ranked program generally increases the likelihood of receiving attractive job offers. This may be in part because the top programs attract the best students in the first place, but also because the doctorate is a research degree and the most highly regarded programs typically have faculty with superior research reputations.

We define program quality in terms of the research reputation of the faculty. This is a common practice. The National Research Council has produced studies of doctoral program quality with a wide variety of measures, but the one most frequently used to rank doctoral programs is the one measuring the scholarly quality of the program faculty as determined by a survey of other academics. U.S. News and World

Reports magazine also produces a ranking of graduate programs using a similar reputational ranking. For eight of the nine groupings of degree fields used in this report we used these two sources, the National Research Council and the U.S. News and World Reports faculty reputational rankings. For one grouping, Agricultural sciences, neither source proved suitable so we used another source. The number of universities defined as top rated varied by program from a low of 20 to a high of 25 programs. The details, including the names of schools that were defined as being highly ranked, are discussed below.

Defining Highly Ranked Doctoral Programs

In general, the U.S. News and World Reports (USN) ranking of doctoral programs was the one used[2]. However, where possible we reviewed the comparable ranking produced by the National Research Council (NRC) in 1995, and added to our list of highly ranked doctoral programs any that were ranked in the top 15 by the NRC but not included within USN's top 20.

One difficulty in using either of these two sources is that most of the nine discipline groupings used in this report are aggregations of several disciplines which were rated separately in the NRC study. In the case of computer science, economics, electrical engineering, and mathematics this was not a problem as each is treated as a separate discipline by both sources of rankings. In the case of life sciences we used the USN rankings for "biological sciences". In the case of "physical sciences" we started with separate rankings for chemistry and physics using USN, then combined the two to get one ranking for "physical sciences". Seventeen of our 22 top-rated physical science schools were in the top twenty for both chemistry and physics. The remainder were ranked in the top 20 in either physics or chemistry and in the top 30 on the other one, or on the NRC ranking of geo-science departments. We used the NRC ranking for electrical engineering programs for our "Electrical and computer engineering" category. The USN reports a single ranking for engineering and that was used for our "Other engineering" category. Our grouping of "Other social sciences" includes all social and behavioral science disciplines except economics. To produce a composite ranking we identified the ranking of the four largest disciplines within this group (psychology, political science, sociology, anthropology) using both sources, then made up a composite list consisting of schools that ranked high in at least three of these disciplines. Eight of these schools were in the top 20 in two of the four social science disciplines examined and in the top 27 in at least one other; the other 16 schools were in the top twenty on either three or on all four of the disciplines.

The agricultural sciences group was treated differently. As there was no suitable match in either the NRC of USN rankings, we used a different source which uses a different methodology to rank academic programs. The ranking used was produced by Academic Analytics, an organization which tracks publication data, including book publications, and uses these to rank graduate program faculty. This grouping of 24 universities includes several land-grant universities which are not included among the high ranked universities for any of our other eight discipline groups.

These rankings differ significantly from the ranking that would result if one tried to identify a list of the top 20 universities across all science and engineering disciplines. Even so, it is possible to take issue with the lists of highly ranked universities for any of the discipline groupings shown below on grounds that some doctorate recipients were in highly rated programs in a specific discipline but their university is not on any of the lists. For example, the University of Delaware is not on our list in "Other engineering" because USN ranked it 41st. However, the NRC ranking which provides separate ranking for 13 distinct engineering sub-disciplines ranked Delaware's chemical engineering faculty as 9th in the nation. It seems these are not necessarily in conflict as the University of Delaware's other engineering departments are not ranked so highly by the NRC. However, a person receiving a doctorate from the University of Delaware's Chemical Engineering program should be classified as graduating from a top-ranked program but will not be because we aggregated all engineering programs except Electrical and computer engineering into one group. Fortunately, this is a fairly extreme and unusual example, but it illustrates the problem.

While the difficulty caused by aggregating disciplines is not trivial, it does not seem likely to have a substantial effect. Even if 5 to 10 percent of doctorate recipients are incorrectly classified because of aggregation of programs (and it would seem to be less than this) a finding that the graduates of the top-

[2] Available at http://grad-schools.usnews.rankingsandreviews.com/grad accessed September, 2008.

rated schools differ little in their stay rate from all other graduates is still of interest. Any misclassification can be viewed as “noise” in the dataset which weakens the result. If, for example, those with doctorates from highly ranked programs stay at below average rates, this “noise” would likely cause a slight underestimate of the difference.

Table A-2. Highly Ranked Universities: Physical Science

California Institute of Technology	U of Chicago
Columbia U	U of Michigan -- Ann Arbor
Cornell U	U of Pennsylvania
Harvard U	U of Texas - Austin
Johns Hopkins U	U. of Illinois-Urbana Champaign
MIT	U. of Wisconsin - Madison
Northwestern U	UC - Santa Barbara
Penn State U - University Park	UC- San Diego
Princeton U	UC-Berkeley
Purdue U	UCLA
Stanford U	Yale U

Table A-3. Highly Ranked Universities: Mathematics

Brown U	U of Illinois - Urbana-Champaign
California Institute of Technology	U of Maryland - College Park
Columbia U	U of Michigan -- Ann Arbor
Cornell U	U of Minnesota - Twin Cities
Harvard U	U of Pennsylvania
MIT	U of Texas - Austin
New York U	U. of Wisconsin - Madison
Northwestern	UC -Berkeley
Princeton U	UC- San Diego
Stanford U	UCLA
U of Chicago	Yale U

Table A-4. Highly Ranked Universities: Agricultural Science

Clemson U	U of Minnesota - Twin Cities
Cornell U	U. of Illinois-Urbana Champaign
Iowa State University	U. of Wisconsin - Madison
Michigan State University	University of Arizona
Montana State University - Bozeman	University of California - Davis
North Carolina State University	University of Connecticut
North Dakota State University	University of Delaware
Purdue U	University of Florida
Rutgers the State University - New Brunswick	University of Kentucky
U of Arkansas, Fayetteville	University of Massachusetts - Amherst
U of Georgia	University of Missouri - Columbia
U of Maryland - College Park	Washington State University

Table A-5. Highly Ranked Universities: Life Science

California Institute of Technology	U of Michigan -- Ann Arbor
Columbia U	U of Pennsylvania
Cornell U	U of Texas Southwestern Medical Center - Dallas
Duke U	U of Washington
Harvard U	U. of Wisconsin - Madison
Johns Hopkins U	UC Berkeley
MIT	UC- San Diego
Princeton U	UC San Francisco
Rockefeller U	Washington U in St Louis
Stanford U	Yale U
U of Chicago	

Table A-6. Highly Ranked Universities: Computer/EE Engineering

California Institute of Technology	U of Maryland - College Park
Carnegie Mellon U	U of Michigan -- Ann Arbor
Columbia U	U of Minnesota - Twin Cities
Cornell U	U of Texas - Austin
Georgia Institute of Technology	U. of Illinois-Urbana Champaign
MIT	U. of Southern California
Northwestern	U. of Wisconsin - Madison
Princeton U	UC - Santa Barbara
Purdue U	UC- San Diego
Stanford	UC-Berkeley
Texas A&M U	UCLA

Table A-7. Highly Ranked Universities: Other Engineering

California Institute of Technology
Carnegie Mellon U
Cornell U
Georgia Institute of Technology
MIT
Northwestern
Princeton U
Purdue U
Stanford
Texas A&M U
U of Maryland - College Park
U of Michigan -- Ann Arbor
U of Texas - Austin
U. of Illinois-Urbana Champaign
U. of Southern California
U. of Wisconsin - Madison
UC - Santa Barbara
UC- San Diego
UC-Berkeley
UCLA

Table A-8. Highly Ranked Universities: Economics

California Institute of Technology
Carnegie Mellon U
Columbia U
Cornell U
Harvard
MIT
New York U
Northwestern
Princeton U
Stanford U
U of Chicago
U of Maryland - College Park
U of Michigan -- Ann Arbor
U of Minnesota - Twin Cities
U of Pennsylvania
U of Rochester
U. of Wisconsin - Madison
UC - Berkeley
UC- San Diego
UCLA
Yale U

Table A-9. Highly Ranked Universities: Other Social Science

Arizona
Columbia
Cornell U
Duke U
Harvard U
Indiana U
Northwestern
Princeton U
Stanford
U of Chicago
U of Michigan -- Ann Arbor
U of Minnesota - Twin Cities
U of Pennsylvania
U of Texas - Austin
U of Washington
U. of Wisconsin - Madison
UC-Berkeley
UC- San Diego
UCLA
UNC
Yale U

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