Foreign Talent in the American Scientific Workforce: Trained Outside of the U.S./Working in the U.S.—Benchmark Data

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By almost any statistic, the United States has been the world's scientific superpower leading other nations in publishing important scientific papers, patenting, and prize-winning. Over the decades of the 1980s and 1990s, for example, "U.S.-based scientists have won the vast majority of important science prizes, including more than two-thirds of the Nobel Prizes in physiology and medicine (Stossel, 1999, p. 17)." Yet, in recent years, signs of weakness in the US scientific enterprise have appeared. The United States has seen its share of scientific publications, industrial patents, and Nobel Prizes falling. For example, while papers produced by U.S. authors[1] grew slowly over the period 1988-1991, growth was negligible over the period 1992-2003.[2] By contrast, over the entire period, the world's output of scientific papers increased by almost 70%,[3] fed by output in the EU-15 -- especially France, Germany and the United Kingdom, and by output in Japan and the emerging East Asian science and technology centers in South Korea, Singapore, Taiwan, and China. As a result, the United States share of world output fell from 38.1% in 1988 to 30.2% in 2003, while the share of world output by the EU-15, Japan, and the East-Asia-4 rose from 37.7% to 48% over the same period.

Although some would argue that the relative declines experienced by the United States are simply "an inevitable result of rising standards of living around the globe (Broad, 2004), data such as these have brought into question the health and vitality of the United States scientific workforce. Of particular concern are two trends: the growing pool

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[1] Authorship is determined by the institutional affiliation of the author at the time the article is published. Fractional counts are used in the discussion that follows.
[2] Between 1992 and 2003, output increased by an annual average rate of 0.6%; however, the rate was -0.2% from 1992-2003 (NSF 07-320, p. 7).
[3] These are calculated from Appendix Table 3, NSF 07-320.

of foreign talent and (2) the declining size and quality of the native-talent pool.[4] While these are not unrelated,[5] here we focus on benchmarking foreign talent in American science.

Defining the scientific workforce is the first step in benchmarking foreign talent in American science. The scientific workforce can be defined in terms of those educated --and at what degree level-- in science and engineering fields, those employed in science and engineering (S&E) occupations, or a combination of the two.[6] In addition, depending upon the research question asked, scientists and engineers may be broadly defined to include those trained and/or working in the social sciences or science-related occupations in addition to those trained or working in the "hard" sciences and engineering.

To serve my long-term interest in studying research productivity in the sciences,[7] I have defined the scientific workforce to include individuals who are employed as scientists and engineers --including postsecondary teachers but excluding social scientists and science-related technologists (except computer programmers) and technicians (both included by NSF) -- in the United States, regardless of their primary field of study or whether they are educated in the U.S. or abroad. Furthermore, I have restricted the workforce to scientists who possess a doctorate or medical degree; engineers, however, need only possess a baccalaureate degree since it is viewed by the profession as being sufficient for research purposes

[4]See, for example, *Science*, 2000, p.43; Zumeta & Raveling, 2002. Indeed, as the global competition for intellectual capital intensifies and countries in Europe and Asia enact policies to keep their scientists at home (Labi, 2004) as well as to lure them from other nations (Piller, 2004), it is clear that the United States must pay more attention to the relative rewards and incentives that affect the recruitment and retention of its exceptional native talent.
[5] See, for example, Levin & Stephan, 1999 or Stephan & Levin, 2001.
[6] Recent work by Kannankutty & Burelli, 2007, does both.
[7] See, for example, Levin & Stephan, 1991.

Data Issues

Although the National Science Foundation (NSF) regularly collects data on different segments of the scientific labor force in its Scientists and Engineers Data System (SESTAT),[8] the only data that includes talent from abroad who have not subsequently received at least a baccalaureate degree in the United States are the postcensal surveys, notably the 1993 National Survey of College Graduates (NSCG) and the 2003 NSCG.[9] Moreover, the NSCG is the part of SESTAT that includes individuals who possess only a medical degree.

Each of these surveys draws a sample of all college graduates from the long form respondents to the previous decennial U.S. population census, with oversampling of those who reported they worked in S&E occupations. The 1993 NSCG was drawn from those residing in the United States on April 1, 1990 or residing abroad as U.S. military personnel; while the 2003 NSCG was similarly drawn with a reference date, however, of October 1, 2003.

The NSCG has a major drawback as a tool for benchmarking foreign talent in the scientific workforce.[10] Since its base sample is only refreshed once every ten-years, there are gaps in our knowledge of how the workforce is changing over the decade between the decennial censuses.[11] Nevertheless, it remains the best available dataset for studying foreign talent in the scientific labor force containing specific information on citizenship

[8]SESTAT [NSF 99-337] also includes new and existing Ph.D.-level scientists and engineers who were educated in the United States (Survey of Doctorate Recipients), as well as new bachelor's and master's degree recipients in science and engineering disciplines as identified by U.S. institutions of higher education (National Survey of Recent College Graduates).

[9]Although postcensal surveys were also conducted in 1972 and 1982, serious issues of sampling bias preclude their usefulness.

[10] In addition, since both associate degrees holders and non-degree holders working in S&E are not sampled, they are underrepresented in the scientific workforce estimates.

[11] Individuals were added to the 1993 base sample in 1995, 1997, 1999 and 2001 only if they received degrees in the United States during these time periods. A similar updating is planned for the 2003 NSCG.

status, the country of birth, the year the individual came to stay in the United States, as well as extensive data on employment and education.

Benchmarking: Using the 1993 NSCG

Paula Stephan and I (Levin & Stephan, 1999; Stephan & Levin, 2001) have used the 1993 NSCG to form benchmarks for assessing whether the foreign-born and foreign-educated were disproportionately represented among those scientists and engineers making exceptional contributions to U.S. science. For a variety of indicators of scientific achievement, we determined whether the observed frequency by birth (educational) origin was significantly different from the frequency one would expect given the composition of the scientific labor force in the United States.

The benchmarks from that project are shown in Table 1.[12] The 1993 NSCG was used to determine the size of the scientific workforce in both 1990 and 1980. For the latter, we restricted the sample to those who immigrated or completed their highest degree before 1980.[13] Distributions are shown for five occupational fields: engineering, the physical sciences (physics and chemistry), mathematical and computer sciences, the earth and environmental sciences and the life sciences (excluding medical practitioners). Overall, 18.3% of the highly-skilled scientists in the United States in 1980 were foreign born. The percent was highest among physical scientists (20.4%) and lowest among life scientists (15.4%). By 1990 the proportion foreign born had increased to 24.7%. The proportion of engineers who were foreign born was substantially smaller than that of

[12] Stephan & Levin, 2001,

[13] While we could have used the 1982 Postcensal Survey for the 1980 estimates, we chose not to do so because the 1993 NSCG was a superior survey in terms of sampling methodology. The 1990 estimates probably overstate the foreign-born component because 1980 respondents who were not in the 1993 sample (died, who left the country) were more likely to be native born than born abroad.

highly-skilled scientists. In 1980 approximately 14% were foreign born; this had crept up to about 16% by 1990.

A striking feature of Table 1 is the large percent of scientists who come to the United States after receiving their doctoral training. In all but mathematics and computer science more than one out of ten individuals in the scientific workforce in 1990 received their doctoral training abroad.

While Table 1 gives us a rough indication of how important the inflow of foreign talent has been to the highly-trained scientific workforce, it was not possible at the time to distinguish between those non-native born individuals who held a temporary visa from those who held permanent residence status either as naturalized citizens or permanent residents when they *first* entered the United States. Yet from a policy perspective, especially given the public's unease over the heavy inflow of foreign talent in some fields of science,[14] it would be desirable to distinguish between those foreign-born individuals who came here as children or as young adults and those who immigrated at later educational or career stages. Fortunately, the availability of the 2003 NSCG permits us to learn much more about the foreign-born component of the scientific workforce and how it has changed over time.

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[14] See, for example, Phillips, 1996; *The Economist*, 1999; Levin et al., 2004.

Table 1. Birth and educational origins of the scientific labor force in the U.S., 1980 and 1990. Estimated from the 1993 NSCG. (%, percent; Bacc.,baccalaureate degree; Ph.D., doctoral/medical degree.)

	1980				1990			
Occupational Field	N	%Foreign Born	%Foreign Bacc.	%Foreign Ph.D.	N	%Foreign Born	%Foreign Bacc.	%Foreign Ph.D.
All Sciences*	55,697	18.3	13.6	8.8	120,888	24.7	16.0	10.7
Earth/Envir. Sciences	4,048	17.6	12.3	19.0	6,976	17.4	9.6	13.5
Life Sciences	14,890	15.4	12.2	9.4	37,717	21.7	12.8	11.6
Math/Comp.Sciences	13,149	18.4	13.9	7.2	31,916	28.5	18.1	7.9
Physical Sciences	23,610	20.4	14.5	7.5	44,279	25.6	18.1	11.6
Engineering†	602,722	13.9	7.4	§	1,108,367	15.9	7.4	§

*Excludes individuals without doctoral or medical degrees, those not in the labor force, those not in the U.S., those in the military, and those in engineering or social science occupations. †Excludes individuals without a baccalaureate degree, those not in the labor force, those not in the U.S., and those in the military. §Engineers do not require training at the doctoral level.

The 2003 NSCG provides responses in an immigration module that adds to the basic information set provided in the earlier NSCG on citizenship status, date came to the United States to stay, and country of birth and citizenship.[15] Of particular importance to determining the composition of the scientific community in the United States are the following new items: the type of visa held when first came to the United States, the temporary visa type, and the year that permanent residency was obtained. Also queried were the factors important in the decision to come to the United States. Thus far NSF has done an excellent job of profiling immigrant scientists, broadly defined (Kannankutty & Burelli, 2007), using data from the latest NSCG. But opportunity exists for further work to be done that sheds light on the foreign component of the scientific labor force, appropriately defined, especially work that focuses on temporary visa holders. Here are some suggestions.

First, we could determine the composition of the scientific labor force by S&E occupation and immigrant status – including the type of visa held upon first arriving in the United States. This is done in Table 2.[16]

[15] There are a few differences between the surveys, most notably in the designation of occupation codes.
[16] As far as possible, definitions similar to those used in 1993 were used in 2003.

Table 2. Birth origins of the scientific labor force in the U.S., 2000. Estimated from the 2003 NSCG. (%, percent.)

			Entry Visa Status of Foreign Born				
Occupational Field	N	% Foreign Born	% Green Card	% Temp. Work	% Study/ Training	% Other Temp.	% Depend.
All Sciences*	372,131	39.6	3.9	3.6	28.2	1.1	2.7
Earth/Envir. Sciences	20,708	28.8	2.1	5.0	20.3	0.0	1.4
Life Sciences	178,590	38.8	3.9	3.0	27.4	0.9	3.5
Math/Comp.Sciences	99,257	47.9	4.8	4.8	34.1	2.0	2.2
Physical Sciences	73,576	33.5	3.4	2.9	24.5	0.8	1.9
Engineering†	1,444,769	19.9	7.2	2.9	7.5	1.1	1.2

*Excludes individuals without doctoral or medical degrees, those not in the labor force, those not in the U.S., those in the military, and those in engineering or social science occupations. †Excludes individuals without a baccalaureate degree, those not in the labor force, those not in the U.S., and those in the military. §Engineers do not require training at the doctoral level. Numbers may not add to totals due to rounding error.

Not surprisingly, Table 2 shows that the incidence of foreign talent has increased in all fields of science as well as in engineering since 1990, from 24.7 to 39.6 percent in the sciences and from 15.9 to 19.9 percent in engineering. Moreover, it appears that the bulk of foreign talent originally entered the United States on either temporary work or study visas, although in engineering, green card holders – most likely for employment reasons – play a significant role in the workforce. While this gives us a good indication of who came from abroad by visa type, the next logical step would be to take a look back and determine what percentage of temporary visa holders, by type, date of entry and scientific field, ultimately transitioned to permanent residence status.

Further insight into how the scientific labor force has changed over time by S&E occupation and immigration status can be obtained by sorting the data into groups who arrived prior to 1970, between 1970 and 1980, between 1980 and 1990, and between 1990 and 2000.[17] Similarly, one could also study the flow of foreign talent from different countries or regions of the world to see how these flows have been changing over time. While all these estimates will be biased to some degree (see footnote 13), with appropriate caveats, they can still be useful additions to our knowledge base.

Another line of investigation could examine the prevalence of foreign talent (controlling for immigration status and visa type) by S&E field of employment and by highest level of education earned in an attempt to determine whether foreign talent are more important to the scientific labor force, broadly defined, at the doctoral, masters, or baccalaureate levels. It would also be possible to determine whether foreign talent (by

[17] Data from the1993 NSCG could also be examined as a rough check on the robustness of these newer estimates.

immigration status) are more likely than their native-born counterparts to remain employed in the field they were educated in.

Unfortunately, the Census Bureau plans to eliminate the long form of the decennial census with the 2010 census. Instead, it plans to use the American Community Survey (ACS) as the basis for determining the NSCG sampling frame. Presently, a taskforce convened by NSF is studying the issues involved in using the ACS as the means to obtain data on the S&E workforce. Hopefully, the outcome will be a robust new NSCG, fielded at least once a decade, which provides data comparable to that found in previous surveys.

References

"Best and Brightest Avoiding Science." 2000. *Science,* April 7, 43.

Broad, William. 2004. "U.S. is Losing its Dominance in the Sciences." *The New York Times,* May 3, A1.

"Imported Brains: Alien Scientists Take over the USA!" 1999. *The Economist*, August 21, 24.

Kannankutty, Nirmala and Burrelli, Joan. 2007. "Why did they come to the United States? A Profile of Immigrant Scientists and Engineers". *InfoBrief*, National Science Foundation [NSF 07-324], Arlington, VA.

Labi, Aisha. 2004. "Europe Strives to Keep its Scientist at Home." *The Chronicle of Higher Education*, September 3, B1.

Levin, Sharon and Stephan, Paula. 1991. "Research Productivity Over The Life Cycle: Evidence for Academic Scientists." *American Economic Review*, 81: 114-132.

Levin, Sharon and Stephan, Paula. 1999. "Are the Foreign Born a Source of Strength for U.S. Science?" *Science*, August 20, 1213-1214.

Levin, Sharon, Black, Grant, Winkler, Anne and Stephan, Paula. 2004. "Differential Employment Patterns for Citizens and Non-Citizens in Science and Engineering in the United States: Minting and Competitive Effects." *Growth and Change*, 35: 456-475.

National Science Foundation. 1999. <u>SESTAT</u>*: A Tool for Studying Scientists and Engineers in the United States*. Authors, Kannankutty, Nirmala and Wilkinson, R. Keith. Arlington, VA. [NSF 99-337].

National Science Foundation, Division of Science Resource Statistics. 2007. *Changing U.S. Output of Scientific Articles: 1988-2003*. Authors, Hill, Derek; Rapoport, Alan I.; Lehming, Rolf F.; Bell, Robert K. Arlington, VA. [NSF 07-320].

Phillips, Michael. 1996. "Math Ph.D.'s Add to Anti-Foreigner Wave." *Wall Street Journal*, September 4, A2.

Piller, Charles. 2004. "A Candy Store for Scientists." *Los Angeles Times*, December 9**,** A1.

Stephan, Paula and Levin, Sharon. 2001. "Exceptional Contributions to US Science by the Foreign-Born and Foreign-Eucated." *Population Research and Policy Review*, 20: 59-79.

Stossel, Scott. 1999. “Uncontrolled Experiment; America’s Dependency on Foreign Scientists.” *The New Republic,* March 29, 17-22.

Zumeta, William and Raveling, Joyce. 2002. “The Best and Brightest for Science: Is There a Problem Here?” Washington DC: Commission on Professionals in Science and Technology.