Research in Higher Education, Vol. 48, No. 8, December 2007 (© 2007)
DOI: 10.1007/s11162-007-9055-6

FOREIGN-BORN ACADEMIC SCIENTISTS AND ENGINEERS: PRODUCING MORE AND GETTING LESS THAN THEIR U.S.-BORN PEERS?

Elizabeth A. Corley,*,† and Meghna Sabharwal*

The *Chronicle of Higher Education* recently reported that the number of doctoral degrees awarded in the U.S. rose 3.4 percent in 2004, largely because of an increase in foreign students (Smallwood 2005). Currently, 20.9 percent (National Science Board 2003) of all science and engineering faculty positions at U.S. universities are held by foreign-born scientists (with even larger percentages in computer science and engineering) - and we can expect higher numbers of foreign-born faculty at U.S. universities in the future. In this paper, we use 2001 *Survey of Doctorate Recipients* (SDR) data from the National Science Foundation to compare productivity levels, work satisfaction levels and career trajectories of foreign-born scientists and U.S.-born scientists. The results indicate that foreign-born academic scientists and engineers are more productive than their U.S.-born peers in all areas. Yet, average salaries and work satisfaction levels for foreign-born scientists are lower than for U.S.-born scientists.

KEY WORDS: Science policy; Publication Productivity; Scientific Productivity; Research Policy; Foreign-Born; Work Satisfaction; Survey.

INTRODUCTION

On December 9, 2005 an article appeared in the *Chronicle of Higher Education* titled ''Doctoral Degrees Rose 3.4% in 2004, Survey Finds'' (Smallwood, 2005). This study reported that the rise in doctoral degrees

The use of NSF data does not imply NSF endorsement of the research methods or conclusions contained in this report.

*School of Public Affairs, Arizona State University, 411 N. Central Avenue, Suite 450, Mail Code 3720, Phoenix, AZ, 85004–0687 USA.

†Address correspondence to: Elizabeth A. Corley, School of Public Affairs, Arizona State University, 411 N. Central Avenue, Suite 450, Mail Code 3720, Phoenix, AZ, 85004–0687 USA. E-mail: elizabeth.corley@asu.edu.

0361-0365/07/1200-0909/0

is due largely to an increase in foreign graduate students. Over the past decade, the number of doctorates awarded at U.S. universities has been relatively flat, but that trend is changing with more international students pursuing doctoral degrees in the U.S. (particularly in science and engineering fields). If the recent trend continues, we should expect to see higher numbers of foreign-born faculty members at U.S. universities in the future as many of the graduating doctoral students look for academic positions. With more foreign-born scientists and engineers on the academic job market, universities will likely invest more resources in hiring - and retaining - them. A recent NSF report stated that almost 20 percent of the scientific workforce in the U.S. is foreign-born (National Science Board, 2003). This same report concluded that foreign-born scientists account for 20.9 percent of all science and engineering faculty positions at U.S. universities (with higher numbers of 39 percent and 35 percent in the fields of computer science and engineering, respectively).

There are many potential benefits that can result from the increase in foreign-born scientists in the U.S. academic workforce. Levin and Stephan (1999) argued that foreign-born scientists are increasingly considered to be a source of strength and prosperity for the U.S. as it seeks to maintain its global leadership in science and technology fields. While contributing to a knowledge-based economy in the U.S., foreign-born scientists can also help build ties for collaboration between the scientific communities of their countries and the United States (Lin, 2004). Additionally, the influx of foreign-born scientists into the faculty ranks at universities can have a particularly positive impact on foreign-born students who are looking for mentors with backgrounds similar to their own.

Given the recent increase in the number of international students pursuing doctoral degrees in the U.S. - and the potential benefits of keeping foreign-born scientists and engineers in the U.S. after they graduate - it is somewhat surprising that foreign-born academic scientists have been relatively under-studied in comparison with other under-represented groups in academia (including minority faculty members and female faculty members). This study attempts to fill a gap that currently exists in the literature by examining the productivity and job satisfaction patterns of foreign-born faculty in the sciences and engineering.

The purpose of this paper is to use data from the National Science Foundation's 2001 *Survey of Doctorate Recipients* (SDR) to explore the differences in career trajectories, work satisfaction, productivity levels, and salaries between foreign-born and U.S.-born academic scientists. Since several researchers have shown that work satisfaction is a significant component of faculty retention (Johnsrud and Heck, 1994; Rausch,

Ortiz, Douthitt, and Reed, 1989) this is a particularly important variable in our analyses.

DATA DESCRIPTION

The data for this study were obtained from the 2001 *Survey of Doctorate Recipients* (SDR) that was conducted by the National Science Foundation (NSF). The population for the 2001 survey consisted of all individuals under the age of 76 who received a doctoral degree in science or engineering from a U.S. institution and were residing in the United States on April 15, 2001 (more information on the description of the data collection and sampling design is available at http://www.nsf.gov/statistics/srvydoctoratework). Several variables were used for sample stratification in the survey, including field of degree, sex, race/ethnic identification, disability status, and place of birth (U.S. versus foreign-born). The data collection took place between May 2001 and October 2001 - and all time-anchored questions used April 15, 2001 as the reference date.

The data were collected in two phases. An initial mail survey was sent out to the potential respondents. Then, to measure non-response bias, the non-respondents were interviewed via telephone using a CATI (Computer Assisted Telephone Interviewing) system. There were a total of 31,366 respondents in the full 2001 SDR dataset. For the survey, the response rate was 82.6 percent - and the results are adjusted for non-response bias through the use of statistical weighting techniques.

Before the analysis in this paper was conducted, however, we further limited the dataset to analyze full-time, academic scientists and engineers. We will briefly discuss this filtering process below - and how this filtering process led to a sample size of 7,980. Since the full SDR dataset includes academic and non-academic doctoral recipients, we filtered out all doctoral recipients who did not have academic jobs. For this filtering process, we counted academics as those faculty members working in one of the following: 1) four year college or university, 2) medical school or 3) university research institute. We did not include those faculty members who worked at 2 year colleges or doctoral recipients who worked in business, federal government, or state/local government. We excluded these respondents from our analysis because the structure of academic jobs varies quite drastically between 4 year universities and 2 year colleges. We do not mean to imply that the expectations placed on faculty are more difficult at one of these institution types; they are simply different. While most academics in 2 year colleges spend a large majority of their time teaching, academics in 4 year universities or

research institutes often split their work activities more evenly between research and teaching. After filtering for only those respondents in academic jobs, the original sample size of 31,366 was reduced to 11,897.

We also filtered out all academics that were not in science and engineering fields. Therefore, we included only faculty who reported that their highest degree was in one of the following: 1) Computer and Math Sciences, 2) Life and Related Sciences, including Biological Sciences, 3) Physical and Related Sciences, including Chemistry and Astronomy, and 4) Engineering, including Chemical, Civil, Electric and Electronics, and Mechanical Engineering. This second filtering step yielded a sample size of 8,352.

Lastly, we focused the analysis in this paper on those with full-time jobs. All respondents with part-time jobs were removed from the dataset. This filtering process was used because we analyzed dependent variables like salary and productivity in this paper (which are not comparable across part-time and full-time positions). After completing the three-stage filtering process mentioned above, our non-weighted sample yielded 7,980 cases for academic scientists and engineers who were employed in full-time jobs.

To explore whether women comprised a disproportionate share of faculty in the groups that we excluded from our analysis, we explored the percentage of women in the initial dataset and our filtered dataset. Within the original data set, 30.1 percent of the 31,366 respondents were women. After filtering for full-time, academic scientists and engineers, our sample contained 28.7 percent women. Thus, while the percentage of women in our analysis is slightly smaller than the percentage of women in the full dataset, we still have a sufficient percentage of women in our filtered sample.

The analysis in this paper is largely focused on finding differences between U.S.-born and foreign-born doctoral recipients working in academic environments. Thus, we defined foreign-born scientists as individuals who were on a permanent visa, on a temporary visa, or were naturalized citizens. The U.S.-born scientists were those who were listed as native born U.S. citizens in the dataset. Before presenting the results of our data analysis, we will discuss the hypotheses that we formed based on the existing literature.

There were several reasons why we chose the 2001 SDR dataset for the analysis presented in this paper. First, the data were collected for a large number of doctorate recipients - and this ensured that the dataset contained a significant number of responses from foreign-born scientists. Second, the dataset is relatively new since the data were collected in 2001. Third, our search of the literature indicated that no one has

analyzed the 2001 SDR data with a focus on foreign-born scientists and their work satisfaction levels, productivity levels and career trajectories. Lastly, we chose this dataset because it has variables that provide information on employment patterns, employment sector, salary, work satisfaction, numbers of publications, grants, patents, reasons for taking a post-doctoral fellowship, citizenship status, marital status, race, age, and citizenship.

LITERATURE REVIEW & HYPOTHESES

Career Trajectories

North (1995) has suggested that foreign-born students who get their doctoral degree in the U.S. are more likely to stay in the academic environment - and that they are more likely to begin this career route by taking a post-doctoral fellowship. He concluded that this trend is due largely to the lack of employment opportunities for foreign-born scientists and engineers. Thus, based on North's results, we hypothesized that foreign-born scientists are more likely than U.S.-born scientists to take a post-doctoral fellowship (Hypothesis 1). We also expected to find that foreign-born scientists would be more likely to take a postdoctoral fellowship than their U.S.-born peers because of the lack of availability of full-time academic or industry positions (Hypothesis 2).

Work Satisfaction

Recently, Elder (2005) explored the complexities of the work visa (H1-B) for foreign-born professionals in the United States. For this study, Elder interviewed Harris Miller from the Information Technology Association of America. During the interview, Miller indicated that some U.S.-born IT professionals view their relationship with foreign-born scientists as "us versus them" (Elder, 2005, p. 11). This outlook is similar to the characterization that Laden and Hagedorn (2000) found when collecting data from faculty of color in academe. They found that minority faculty often feel that they are treated differently - and those faculty consistently report lower job satisfaction rates than Caucasian faculty members. Several additional studies have indicated that women and faculty of color are two groups who have lower job satisfaction rates than Caucasian faculty (Bender and Heywood, 2004; Locke, Fitzpatrick, and White, 1983; Olsen, Maple, and Stage, 1995; Turner, 2002).

However, not much research has been done to address the satisfaction levels of foreign-born academic scientists and engineers compared to

native-born U.S. citizens. Hence, we draw here from the general literature on satisfaction among faculty members, and extend our hypotheses to address issues involving foreign-born and U.S. born academic scientists. Drawing on the results of both the Elder (2005) research and the research by Laden and Hagedorn (2000), we hypothesized that foreign-born academic scientists would have lower levels of work satisfaction than U.S.-born academic scientists.

Several studies have also explored the relationship between job satisfaction and individual income (Bender and Heywood, 2004; Kalleberg, 1977; Ward and Sloane, 2000; Watson and Meiksins, 1991), job autonomy (Meiksins and Watson, 1989), job security (Handel, 2005), and the amount of challenge at work (Lee, 1992; Watson and Meiksins, 1991) for academics. In this paper, we examine each of the above variables - and explore the relationship with level of work satisfaction among both foreign-born and U.S.-born academic scientists. Since work satisfaction can indirectly impact productivity and success levels for faculty members, we also explore the differences in productivity levels for foreign-born and U.S. born academic scientists. Since past studies have shown that other under-represented faculty (including women scientists and minority scientists) have lower average work satisfaction levels (Astin, Antonio, Cress, and Astin, 1997; Carr, Ash, Friedman, Scaramucci, Barnett, Szalacha, Palepu, and Moskowitz, 1998), we hypothesized that foreign-born scientists would also have lower satisfaction levels than U.S.-born scientists (Hypothesis 3).

Productivity For Academic Scientists

Productivity levels for faculty have been studied as a function of age (Diamond, 1986; Levin and Stephan, 1989; Meltzer, 1949), gender (Bellas and Toutkoushian, 1999; Cole and Zuckerman, 1991; Cole and Singer, 1991; Cole and Zuckerman, 1984; Long and Fox, 1995; Sonnert, 1995; Stack, 2004; Xie and Shauman, 1998; Zuckerman, 1991), marital status (Astin and Davis, 1985; Clark, 1986; Cole and Zuckerman, 1984; Cole and Zuckerman, 1987; Ginther and Hayes, 1999; Mason and Goulden, 2004; Stack, 2004), tenure (Clark and Lewis, 1985; Levitan and Russ, 1992), time spent on research and development (Andrews, 1964; Fox, 1992; Hattie and Marsh, 1996; Marsh and Hattie, 2002), prestige and type of institution (Long, Allison, and McGinnis, 1979; Long, 1978; Xie and Shauman, 1998), and discipline (Keith, Layne, Babchuk, and Johnson, 2002; Wanner, Lewis, and Gregorio, 1981). Yet, relatively few studies have looked specifically at citizenship and its impact on research productivity (for examples of studies that have dealt

with this, see Lee, 2004; Levin and Stephan, 1999; Stephan and Levin, 2001). In this study we use many of the above variables to predict the publication productivity of foreign-born and U.S-born scientists in our sample.

In terms of contribution there is no denying that foreign-born scientists have contributed much to the fields of science and engineering. Levin & Stephan (1999) concluded that a large number of individuals making contributions to science and engineering fields are disproportionately foreign-born - particularly, in terms of highly cited patents, highly cited articles, and membership in prestigious academies such as the National Academy of Sciences (NAS) and National Academy of Engineering (NAE). Similar findings were confirmed by Lee (2004), who found that foreign-born scientists have greater publication productivity (27 percent more) than U.S.-born scientists, with results varying with the scientist's nation of origin. Based on these studies, we hypothesized that foreign-born academic scientists would be more productive than the U.S.-born scientists when productivity is measured as 1) number of articles, 2) number of books, 3) number of conference papers, 4) grants, and 5) patents (Hypothesis 4).

Primary Work Activity: Research or Teaching

By analyzing the employment patterns of immigrants and U.S. citizens, North (1995) found that U.S. citizens were more likely to be employed in management-based positions, while immigrants were more likely to be employed in R&D. Even though these results are not specific to academic faculty, we used North's findings to hypothesize that foreign-born academic scientists were likely to spend more time on R&D and less time on teaching when compared with the U.S.-born scientists (Hypothesis 5).

Since academic faculty are often hired to both conduct research and teaching, one might expect that time spent on one of these activities is time taken away from the other (see Hattie and Marsh, 1996 for a meta-analysis of the relationship between teaching and research). Both Fox (1992) and Marsh & Hattie, (2002) found that publication productivity has 1) an inverse relationship with the amount of time invested in teaching and 2) a direct positive relationship with the amount of time spent on research activities. Fox concluded that research and teaching are two different aspects of academic investments "at some odds with each other" (Fox, 1992, p. 303).

Often the amount of time that a faculty member spends on teaching and research is not completely an individual choice, but rather is

dictated by the type of institution and the teaching load at that institution. Xie and Shauman (1998) found that the type of institution at which the faculty member is employed impacts the individual's level of research productivity. We expect that this effect is at least partially due to the amount of time that faculty have to spend on research and teaching. This phenomenon has been studied extensively within the literature on women scientists because several researchers have found that female scientists are more likely than male scientists to end up at a teaching institution - or in a lower ranking (non-tenure track or non-tenured) position (Bentley and Adamson, 2003; Miller-Loessi and Henderson, 1997). Based on this research, we thought it best to measure institutional affiliation and the teaching time/research time ratio separately by observing 1) whether or not a respondent was employed by a Carnegie Research I or II institution and 2) whether the primary work activity was research or teaching.

Patents and Research Grants

Another important indicator of productivity is the number of research grants and patents awarded to faculty members. A study conducted by Liebert (1977) established a direct positive relationship between the amount of grant activity and the number of articles published. Norris (2004) explored the relationship between grant acquisition and citizenship. She found that level of grant activity is more strongly (and positively) correlated with publication productivity for U.S.-born academics than for foreign-born academics. Even though Norris (2004) found that the relationship between grant funding and publication productivity is stronger for U.S.-born scientists, this does not mean that foreign-born scientists are receiving fewer grants. In fact, Lee (2004) found that there was no significant difference in grant amounts and grant acceptance rate between native U.S. scientists and foreign-born scientists.

Publications and grants are only two measures of productivity for university faculty members. Another commonly used measure is patent activity. Recently, Stephan, Sumell, Black, and Adams (2004) sought to answer the question "who is patenting in universities?" They used data from the 1995 NSF *Survey of Doctorate Recipients* for their study. Stephan and colleagues (2004) showed a positive (and significant) relationship between number of patents and number of publications. Their study included citizenship as one of the explanatory variables to measure patenting activity, but they did not report any specific results based on citizenship in the paper. Based on the above-mentioned research, we hypothesized that foreign-born scientists would be less likely than U.S.-

born scientists to have patents and grants, partially because citizenship is an important criteria of getting funding for some defense-related projects (Hypothesis 6).

Now we turn to another measure of success within the academy: salary. While publications, grants, and patents are measures of success - and they help faculty members attain tenure and promotion - salary can also be a measure of success. Additionally, salary can be explicitly linked to work satisfaction variables (and we explore that relationship later in the paper).

Salary of Academic Scientists and Engineers

Salary for academic faculty has been studied by social scientists within a variety of settings - and for many purposes. However, one of the areas within which salary has been studied the most is gender. Many scholars have explored how salaries differ across male and female faculty members (Barbezat, 2002; Ferber and Green, 1982; Ginther and Hayes, 1999; Hoffman, 1976; Katz, 1973; Perna, 2001; Toutkoushian, 1998; Toutkoushian and Conley, 2005). Some recent studies have shown that the gender gap in academic salaries is narrowing.

Using data from the 1999 *National Study of Postsecondary Faculty*, Toutkoushian and Conley (2005) found no statistical significance for gender-based discrimination in salaries among doctoral-level institutions or liberal arts institutions. However, they did uncover a significant wage gap between male and female faculty members working in Carnegie Research I or II institutions, even when controlling for years of experience, educational attainment, discipline, rank, and institution type. After controlling for various work related variables, they still found that women earned 4-6 percent less than men. Based on the above mentioned studies, we hypothesized that the male scientists would earn more than the female scientists in our sample (Hypothesis 7).

Apart from gender differences, other scholars have shown that pay disparity among faculty members can be a function of a number of variables, including type of institution (Toutkoushian, 1998; Toutkoushian and Conley, 2005), discipline (Ginther, 2004; Toutkoushian, 1998; Toutkoushian and Conley, 2005), rank (Bellas, 1993; Ginther and Hayes, 1999; Loeb, Ferber, and Lowry, 1978; Tuckman and Tuckman, 1976), years since Ph.D. (Katz, 1973; Strathman, 2000), and citizenship (Borjas, 1994; Espenshade, Usdansky, and Chung, 2001). Toutkoushian and Conley (2005) showed that a wage gap existed among male and female faculties employed in Carnegie Research I or II institutions when compared with a less research-intensive university. Extending their

findings to academic scientist and engineers, we hypothesized that faculty at Carnegie Research I or II institutions would earn more than faculty employed at less research-intensive universities (Hypothesis 8).

Espenshade and colleagues (2001) studied the employment differentials among all U.S.-born and foreign-born scientists. They found that after controlling for level of education and location, foreign-born scientists earned 2.1 percent more than U.S.-born scientists in 1996. However, when they controlled for demographic and other socioeconomic factors (like age, race, sex, marital status, and English language proficiency), they found that foreign-born scientists earned 9.3 percent less in 1996. While Espenshade and colleagues (2001) did analyze data for foreign-born and U.S.-born employees in science and engineering, they did not restrict their analysis to only academic scientists. Yet, we believe that their results are more relevant for our analysis than any other recent research so we used them to develop our hypothesis that foreign-born scientists would earn more than the U.S.-born academic scientists (Hypothesis 9). All of the hypotheses outlined in this section are summarized in Table 1.

FINDINGS

After filtering for scientists or engineers in full-time academic positions, 76.7 percent of the respondents in the dataset were U.S.-born and 23.3 percent were foreign-born. Except when explicitly indicated, all results presented in this paper were computed using the weighting variable created by the NSF. The sampling weights were provided by the NSF - and they are defined as the reciprocal of the probability of selection for each sampled unit. The weights were adjusted by using weighting class or post-stratification adjustment procedures. Additional information on the weighting strategy can be found at http://srsstats.sbe.nsf.gov/docs/techinfo.html#2001SDRDesign.

About 23 percent of the sample respondents were female and about 77 percent were male. The overall sample was 80.3 percent Caucasian, 14 percent Asian, 2.5 percent African American, 2.9 percent Hispanic, and 0.3 percent Native American. Additionally, the largest portion of the sample received their highest degree in the Life Sciences (50.5 percent of respondents) or Physical Sciences (22.2 percent of respondents). These two fields were followed by Engineering (16.3 percent of respondents) and Computer/Math Sciences (11 percent of respondents). The respondents held a variety of academic positions, including Full Professor (35 percent), Associate Professor (21.6 percent), Assistant Professor (19.4 percent), Instructor (1.8 percent), Lecturer (1.0 percent), Adjunct

TABLE 1. Summary Table of Hypotheses

Number	Hypothesis	Verified or Falsified by Analysis?
1	Foreign-born scientists are more likely to have a post-doctoral position.	Verified
2	Foreign-born scientists are more likely to take a post-doc because of the low availability of other employment.	Verified
3	Foreign-born scientists have lower work satisfaction levels than U.S.-born scientists.	Partially Verified for Post-Docs; Verified for Non-Post-Docs
4	Foreign-born scientists are more productive than U.S. born scientists.	Partially Verified for Post-Docs; Verified for Non-Post-Docs
5	Foreign-born scientists are more likely to report R&D as their primary work activity.	Verified
6	Foreign-born scientists are less likely than U.S.-born scientists to have patents and grants, partially because citizenship is an important criteria of getting funding for some defense-related projects.	Falsified
7	Male scientists have higher salaries than female scientists.	Verified
8	Faculty at Carnegie Research I or II institutions earn more than faculty employed at less research-intensive universities.	Verified
9	Foreign-born scientists earn higher salaries than U.S.-born academic scientists.	Falsified

Faculty (1.4 percent) and Other (19.9 percent). Within the questionnaire, respondents were asked if they were in a post-doc position during the survey (the week of April 15, 2001). This question was asked separately from the faculty rank question. About 10 percent of the sample held post-doctoral positions during the data collection process. Slightly more than half of the respondents (52.9 percent) worked at a Carnegie Research I or II institution.

Table 2 presents a detailed descriptive analysis of several work and demographic variables as a percentage of the two groups of interest:

TABLE 2. Summary Data for Academic Scientists and Engineers in Sample

	U.S.-Born				Foreign Born			
	Weighted		Un-Weighted		Weighted		Un-Weighted	
Characteristic	Total *N*	%	Total *N*	%	Total *N*	%	Total *N*	%
Gender								
Male	92,576	76.2	4,510	71.8	29,007	78.7	1,180	69.4
Female	28,915	23.8	1,769	28.2	7,871	21.3	521	30.6
Ethnicity								
White	114,051	93.9	4,978	79.3	13,084	35.5	1,701	100.0
Hispanic	2,533	2.1	443	7.1	2,139	5.8	611	35.9
Black	2,289	1.9	447	7.1	1,608	4.4	105	6.2
Asian	2,113	1.7	311	5.0	20,005	54.2	81	4.8
Native American	425	0.3	90	1.4	42	0.1	901	53.0
Other	80	0.1	10	0.2	0	0	0	0
Disciplinary Field								
Computer and Math Sciences	12,445	10.2	696	11.1	5,025	13.6	251	14.8
Life and related Sciences	64,298	52.9	3,250	51.8	15,668	42.5	712	41.9
Physical and related Sciences	27,672	22.8	1,412	22.5	7,428	20.1	347	20.4
Engineering	17,076	14.1	921	14.7	8,757	23.7	391	23.0
Faculty Rank								
Professor	44,959	37.0	2,043	32.5	10,410	28.2	451	26.5
Associate Professor	26,984	22.2	1,395	22.2	7,283	19.8	324	19.0
Assistant Professor	23,017	18.9	1,361	21.7	7,771	21.1	378	22.2
Instructor	1,768	1.5	100	1.6	1,006	2.7	48	2.8
Lecturer	1,240	1.0	71	1.1	271	0.7	15	0.9
Adjunct	1,767	1.5	83	1.3	441	1.2	21	1.2
Other	21,755	17.9	1,226	19.5	9,695	26.3	464	27.3
Employed as a Post-doc at time of survey	8,760	7.2	565	9.0	6,531	17.7	307	18.0
Carnegie Classification of Employer (Research I or II University)	62,509	51.5	3,164	50.4	21,243	57.6	967	56.8

Total *N* for Weighted = 158,368 (121,491 U.S.-born scientists and 36,878 Foreign-born scientists).

Total *N* for Un-weighted = 7,980 (6,279 U.S.-born scientists and 1,701 Foreign-born scientists).

All differences across U.S.-born and foreign-born scientists significant at 0.05 level for weighted values (using χ^2-test) .

U.S.-born scientists and foreign-born scientists. Focusing on the weighted data, about 58 percent of foreign-born scientists were employed in a Carnegie Research I or II institution compared with about 52 percent of U.S. born scientists. Additionally, foreign-born scientists were more likely than U.S. born scientists to be in the fields of Computer/Math Sciences and Engineering, while U.S. born scientists had higher levels of representation in the Life and Physical sciences.

The table also shows that U.S. born scientists were more likely to hold high-level academic positions than foreign-born scientists. While 59.2 percent of U.S. born scientists held full or associate professorships, only 48 percent of foreign-born scientists held those positions. Interestingly, however, slightly more foreign-born scientists held assistant professorships (21.1 percent) when compared to U.S. born scientists (18.9 percent). We speculate that this transition between senior level faculty and junior level faculty means that universities are hiring more international doctoral students as new faculty members (which meshes with the results in the *Chronicle of Higher Education* article presented at the beginning of this article). Additionally, about 17.7 percent of foreign-born scientists were post-docs compared with 7.2 percent of U.S. born scientists. This result verifies our first hypothesis that foreign-born scientists would be more likely to have post-doctoral positions.

There were several demographic variables that differed across the two groups as well. A slightly higher percentage of the foreign-born scientists (78.7 percent) were males when compared to the percentage of males in the U.S. born group (76.2 percent). Also, U.S. born scientists were, on average, about 3.5 years older than foreign-born scientists (47.7 years old versus 44.2 years old). The salaries differed for the two groups, with U.S. born scientists earning, on average, about $74,388 per year and foreign-born scientists earning about $67,597 per year.

To further explore why there are fewer foreign-born scientists in higher ranking positions we wanted to examine possible cohort effects that could distort differences in career trajectories. For example, a younger cohort might have more foreign-born scientists than an older cohort - and younger scientists are more likely to be in lower-level positions. In Table 3, we divided the dataset into two cohort groups: early-to-mid career and mid-to-late career. We distinguished between these two cohort groups by computing the median ''year of highest degree'' for the full sample. This median year was 1986. Then, we divided the sample into two cohort groups. In particular, we identified early-to-mid career scientists as those who received their highest degree in 1986 or after. Conversely, we defined mid-to-late career scientists as those who received their highest degree before 1986.

TABLE 3. Summary Data for Academic Scientists and Engineers by Cohort Groups

	U.S.-Born				Foreign Born			
	Early to Mid Career		Mid to Late Career		Early to Mid Career		Mid to Late Career	
Characteristic	Total *N*	%	Total *N*	%	Total *N*	%	Total *N*	%
Gender								
Male	38,760	66.1	53,816	85.7	18,369	74.4	10,638	87.2
Female	19,922	33.9	8,993	14.3	6,313	25.6	1,558	12.8
Ethnicity								
White	53,936	91.9	60,115	95.7	7,815	31.7	5,269	43.2
Hispanic	1,585	2.7	948	1.5	1,564	6.3	574	4.7
Black	1,348	2.3	941	1.5	1,117	4.5	491	4.0
Asian	1,494	2.5	619	1.0	14,181	57.5	5,823	47.7
Native American	264	0.4	161	0.3	4	0.0	38	0.3
Other	55	0.1	25	0.0	0.0	0.0	0.0	0.0
Disciplinary Field								
Computer & Math Sciences	5,238	8.9	7,207	11.5	3,384	13.7	1,641	13.5
Life and related Sciences	32,991	56.2	31,307	49.8	11,624	47.1	4,044	33.2
Physical and related Sciences	12,414	21.2	15,259	24.3	4,494	18.2	2,934	24.1
Engineering	8,040	13.7	9,036	14.4	5,180	21.0	3,577	29.3
Faculty Rank								
Professor	3,932	6.7	41,027	65.3	2,115	8.6	8,295	68.0
Associate Professor	14,643	25.0	12,341	19.6	5,029	20.4	2,255	18.5
Assistant Professor	21,067	35.9	1,949	3.1	7,391	29.9	380	3.1
Instructor	1,572	2.7	196	0.3	934	3.8	72	0.6
Lecturer	769	1.3	471	0.8	264	1.1	7	0.1
Adjunct	1,074	1.8	694	1.1	273	1.1	168	1.4
Other	15,625	26.6	6,130	9.8	8,675	35.1	1,020	8.4
Employed as a Post-doc at time of survey	8,629	14.7	131	0.2	6,499	26.3	32	0.3
Carnegie Classification of Employer (Research I or II University)	30,137	51.4	32,372	51.5	14,616	59.2	6,627	54.3

All differences across U.S.-born and foreign-born scientists (within same career stage) are significant at 0.05 level except for the following for Mid-to-Late Career Scientists: ''Native American,'' ''Physical Sciences,'' ''Assistant Professor,'' and ''Post Doc.''.

The results in Table 3 demonstrate that the nationality (foreign-born versus U.S.-born) differences in faculty rank are more pronounced for early-to-mid career scientists than they are for mid-to-late career scientists. In fact, for the mid-to-late career scientists a higher percentage of foreign-born scientists are full professors than their U.S.-born peers (68 percent compared with 65.3 percent). Even though the U.S.-born scientists were slightly more likely to be Associate professors, the two groups had equal percentages of Assistant Professors (3.1 percent). The differences in career trajectories were most prevalent for the early-to-mid career scientists. A slightly higher percentage of young foreign-born scientists had full professorships (8.6 percent compared with 6.7 percent for U.S.-born young scientists), but they were less likely to be in Associate and Assistant professor Positions.

Also, when focusing on the younger cohort of scientists, we can see that a much higher percentage of foreign-born scientists were in a post-doctoral position (26.3 percent compared with 14.7 percent for young U.S.-born scientists). These results further confirm our first hypothesis that the foreign-born scientists would be more likely to have post-doc positions. Also, for both foreign-born and U.S.-born scientists there are about twice as many female scientists in the early-to-mid career cohort as there is in the mid-to-late cohort. This shows that for both foreign-born and U.S.-born groups, women are increasingly entering academic faculty ranks.

The Role of Post-Doctoral Fellowship

Using results by North (1995), we hypothesized that there would be a higher percentage of foreign-born scientists with post-doctoral fellowships. As we just demonstrated, our results confirmed this hypothesis. North (1995) concluded that this trend is largely due to the lack of employment opportunities for foreign-born scientists and engineers. To further explore employment opportunities for U.S.-born and foreign-born post-docs, we conducted a Chi-square test to determine the reasons why scientists pursue and accept post-doctoral positions after completing their doctoral. The results are presented in Table 4 - and they represent only those respondents who were employed as post-doctoral fellows during the week of April 15, 2001.

The table demonstrates that, overall, foreign-born and U.S-born scientists chose different reasons for taking a postdoctoral fellowship. The most common reason why both foreign-born (about 80 percent) and U.S. born scientists (about 85 percent) took a post-doctoral position was because that career path was generally expected in their field.

TABLE 4. Reasons for Pursuing and Accepting a Post-Doctoral Fellowship

Reasons for Taking a Post-Doc	Percent U.S.-Born Scientists (N = 8,760) (Sample Size)	Percent Foreign-Born Scientists (N = 6,531) (Sample Size)
Other employment not available	20.2 (1,766)	34.9 (2,281)
Generally expected for a career in the field	84.5 (7,399)	80.4 (5,253)
To work with a specific person	79.4 (6,956)	53.4 (3,490)
To get additional training in Ph.D. field	77.2 (6,760)	69.9 (4,564)
To get training in an area outside Ph.D.	47.4 (4,153)	43.6 (2,848)

All Chi-Square values indicate significant differences across U.S. born and Foreign-Born Scientists (with $p < .001$ and $df = 1$).
Percentages reflect the response to each individual item and, therefore, do not add up to a 100 percent. Also, all percentages based only on those who had post-doc at time of survey.
Weighted sample sizes are in parentheses after percentages.

The second most common reason why U.S.-born scientists took a post-doctoral position was to work with a specific person (about 80 percent). However, for foreign-born scientists this reason for accepting a post-doctoral position was less common (about 53 percent) than the desire to get additional training in the field (about 70 percent). Since respondents could choose multiple reasons for taking a post-doctoral fellowship, the percentages within groups total more than 100 percent.

For both groups, the least common reason for taking a post-doctoral fellowship was because other employment was not available. Even though this is the least common reason, the percentage of foreign-born post-docs who said that the lack of other employment impacted their decision to take a post-doc (about 35 percent) was significantly higher than the same percentage of U.S.-born post-docs (about 20 percent).

These results confirm our hypothesis that foreign-born scientists were more likely to take a post-doc because of lack of other employment opportunities. Also, this finding is consistent with North's (1995) results; he argued that foreign-born scientists have a more difficult time finding full-time employment because of their visa and citizenship status. The preferred route taken by some of these individuals could be to locate a post-doctoral position with a professor that the student already knows.

To explore in closer detail the reasons why individuals take up post-doctoral positions, we analyzed the primary and secondary reasons provided by the two groups. The results of this analysis are presented in Table 5. Our findings suggest that the foreign-born and U.S.-born academic scientists differed significantly in the primary and secondary

TABLE 5. Primary and Secondary Reasons Why Respondents Took Post-Doctoral Position

	Primary Reason		Secondary Reason	
Reasons for taking a Post-doc	Percent U.S. Born Scientists (Sample Size)	Percent Foreign Born Scientists (Sample Size)	Percent U.S. Born Scientists (Sample Size)	Percent Foreign Born Scientists (Sample Size)
Other employment not available	6.7 (590)	14.6 (957)	6.9 (577)	11.8 (715)
Generally expected for a career in the field	32.9 (2882)	31.3 (2047)	19.6 (1631)	27.7 (1679)
To work with a specific person	25.3 (2218)	14.7 (958)	26.0 (2167)	22.4 (1357)
To get additional training in Ph.D. field	19.1 (1675)	22.5 (1471)	27.4 (2285)	23.3 (1411)
To get training in an area outside Ph.D.	11.6 (1015)	14.7 (957)	18.5 (1543)	14.0 (850)
Other	4.3 (380)	2.1 (140)	1.6 (131)	0.8 (51)

Weighted sample sizes are in parentheses after percentages. Responses and percentages are only for those who are currently in a post-doc at time of survey administration. .

All Chi-Square values indicate significant differences across U.S. born and Foreign-Born Scientists (with $p < .001$ and $df = 1$).

reasons they provided for taking a post-doctoral position. While only 13.6 percent of U.S.-born scientists listed ''other employment not available'' as the primary or secondary reason for taking a post-doctoral position, 26.4 percent of the foreign-born scientists listed it as their primary or secondary reason. Overall the results suggest that foreign-born and U.S.-born scientists are most likely to take a post-doctoral position because of the following reasons: it is generally expected in the field they are in, their need for additional training, or to work with a specific person. Yet, foreign-born scientists were much more likely than U.S. born scientists to take a post-doctoral position because there were no other employment opportunities available to them. In sum, the results presented in Tables 4 and 5 confirmed our second hypothesis that foreign-born scientists would be more likely to take a post-doctoral position because of the low availability of other employment.

Work Satisfaction

Several scholars have studied work satisfaction levels for faculty members (Hagedorn, 2000), including part-time or non-tenure track faculty (Antony and Valadez, 2002; Gappa, 2000), female faculty (August and Waltman, 2004; Hagedorn, 1996 ; Olsen, Maple, and Stage, 1995; Ropers-Huilman, 2000), minority faculty (Laden and Hagedorn, 2000; Olsen, Maple, and Stage, 1995; Palepu, Carr, Friedman, Ash, and Moskowitz, 2000), and medical faculty (Nyquist, Hitchcock, and Teherani, 2000; Palepu et al., 2000). However, little of the previous research has focused on specific differences in work satisfaction levels between foreign-born and U.S.-born academic scientists. Based on previous studies, we hypothesized that foreign-born scientists would also have lower satisfaction levels than U.S.-born scientists. This hypothesis was confirmed by our data analysis.

Previous research has shown that post-docs tend to have lower levels of work satisfaction than scientists with full-time, permanent positions so we wanted to make sure that we analyzed post-docs separately from other scientists. We found that when we excluded post-docs from the analysis foreign-born scientists were significantly less satisfied than U.S.-born scientists on all dimensions of the work environment, including opportunities for advancement, job benefits, intellectual challenge of the job, degree of independence, location, level of responsibility, salary, job security, and contribution to society. The results of our t-test comparison between foreign-born and U.S.-born scientists are presented in Table 6.

TABLE 6. Comparison of Work Satisfaction Variables for Foreign-Born Academic Scientists and U.S.-Born Academic Scientists

	Satisfaction with Variable U.S.-Born Scientists		Satisfaction with Variable Foreign Born Scientists	
Work Satisfaction Measures	Currently Post-Doc (N = 8,760)	Not Currently Post-Doc (N = 112,731)	Currently Post-Doc (N = 6,531)	Not Currently Post-Doc (N = 30,347)
Opportunities for advancement	2.53	2.99	2.72	2.92
Benefits	2.73	3.26	2.68	3.16
Intellectual Challenge	3.61	3.56	3.41	3.43
Degree of Independence	3.51	3.68	3.36	3.62
Location	3.26	3.41	3.31	3.29
Level of Responsibility	3.38	3.51	3.21	3.37
Salary	2.41	2.96	2.25	2.76
Job Security	2.61	3.43	2.63	3.30
Contribution to Society	3.24	3.57	3.26	3.54

Comparisons across post-doc foreign-born and U.S.-born scientists are statistically significant at the 0.05 level except for "job security" and "contribution to society." All comparisons across non-post-doc foreign-born and U.S.-born scientists are statistically significant at the 0.05 level. Results are in response to the following question "Thinking about your principal job held during the week of April 15, 2001, please rate your satisfaction with that job's ….".
Possible responses: 1 = very dissatisfied; 2 = somewhat dissatisfied; 3 = somewhat satisfied; 4 = very satisfied.

These results are consistent with previous research on work environment variables that showed that women faculty and minority faculty (both under-represented groups as are foreign-born scientists) tend to have lower job satisfaction levels than white males do (Bender and Heywood, 2004; Corley, 2005; Laden and Hagedorn, 2000; Locke, Fitzpatrick, and White, 1983; Olsen, Maple, and Stage, 1995; Turner, 2002).

Measures of Productivity

Productivity is an important outcome measure among faculty members and is often used as a gauge to evaluate the level of success for promotion and tenure in academe. For our analysis in this paper, we define productivity as the number of publications between April 1995 and April 2001 (which was a variable in the 2001 SDR dataset). We

performed t-tests and Chi square tests to assess the productivity levels of foreign-born and U.S.-born scientists in the dataset.

The findings from our t-tests are reported in Table 7. In this table we report averages for each of the productivity measures (including articles, books, papers and patent activity). Since the majority of these variables were created by asking the respondents to report how many of the output measures they produced between April 1995 and April 2001 (the time of the survey), we decided to compute annualized productivity measures to allow us to control for different Ph.D. graduation dates. This decision was made largely because the average age for the respondents differed across U.S. born and foreign-born groups. Therefore, respondents who received doctoral degrees before 1995 would have had the full six years to publish, but the respondents who received their degrees since 1995 would not have had the full six years to publish. The equations used to compute these annual averages are listed in Table 7.

We have also separated out productivity measures for post-docs and non-post-docs in Table 7. This is because post-docs are more likely to work solely on research and devote more time to publishing (because of the nature of their position). Since a higher percentage of foreign-born scientists were post-docs (17.7 percent of all foreign-born respondents compared with 7.2 percent of all U.S.-born respondents), we believed it was important to analyze the post-doc groups separately from the other scientists and engineers.

The results clearly demonstrate that those in post-doctoral positions did publish more articles and conference papers than those in other positions. The results across nationality are also interesting. For those with post-doctoral positions, there were no significant productivity differences across U.S.-born and foreign-born scientists except for the number of U.S. patent applications: foreign-born post-docs submitted an annual average of 1.5 patent applications compared with an average of 0.59 for U.S.-born post-docs. On the other hand, there were significant productivity differences across U.S.-born and foreign-born scientists who were not in post-doctoral positions (i.e., 90 percent of the sample).

For all measures of productivity, foreign born scientists who were not in post-doc positions were significantly more productive than their U.S.-born peers. The foreign-born scientists published an annual average of 2.09 articles while the U.S.-born scientists published an average of 1.64. When we used number of books and conference papers as measures for productivity, the trend continued. The foreign-born scientists averaged annually 0.03 more books and 0.64 more conference papers than the U.S.-born scientists. These results confirm the findings by other

TABLE 7. Comparison of Productivity Measures for Foreign-Born and U.S. Born Academic Scientists

	U.S.-Born Scientists		Foreign-Born Scientists	
Measures *(Annual Averages Between April 1995 and April 2001)*	Mean for Post-Docs	Mean for Non-Post-Docs	Mean for Post-Docs	Mean for Non-Post-Docs
Sample Sizes for Publication Data	**8,760**	**112,731**	**6,531**	**30,347**
Number of Articles published or accepted for publication in a refereed journal	2.35	1.64	2.30	2.09
Number of Books or monographs published or accepted for publication	0.09	0.11	0.09	0.14
Number of Papers presented at a regional, national or international conference	2.87	2.16	2.89	2.80
Patent data are reported only for those respondents who had been named as an inventor on an application for a U.S. patent at the time of the survey.				
Sample Sizes for Patent Data	**844**	**13,731**	**626**	**4,647**
Number of U.S. patent applications where respondent is named as inventor	0.59	0.42	1.50	0.62
Number of U.S. patents granted where respondent is listed as inventor	0.24	0.25	0.25	0.43
Number of U.S. patents that resulted in commercialized or licensed products	0.05	0.10	0.05	0.19

For those with highest degree granted in or before 1995, Annual Number = (Total Between 2001 and 1995) / 6 years. For those with highest degree granted after 1995, Annual Number = (Total Between 2001 and 1995) / (2001-Year of Highest Degree).
The only annual productivity difference across post-docs for foreign-born and U.S.-born scientists that is statistically significant at the 0.05 level (using t-test) is "Number of U.S. patent applications (per individual) where respondent is named as inventor."
All productivity differences across non-post-docs for foreign-born and U.S.-born scientists are statistically significant at the 0.05 level (using t-test).

researchers (Lee, 2004; Levin and Stephan, 1999; North, 1995; Stephan and Levin, 2001) who found that foreign-born scientists are more productive than U.S.-born scientists.

This trend of high productivity among foreign-born scientists continued when we took grants and patents as the measures of productivity. Foreign-born scientists were significantly more likely to be named as an inventor on a U.S. patent (14.3 percent compared with 12 percent for U.S.-born scientists). Similarly, foreign-born scientists were slightly more likely to receive grants than U.S.-born scientists, with 58 percent of the foreign-born scientists being awarded governmental grants compared with 55.5 percent of U.S.-born scientists. These results are different from the findings by Lee (2004), who showed that there is no significant difference in grant acceptance and funding amounts between foreign-born and U.S.-born scientists.

Additional results on the annual number of patents produced are presented in the bottom half of Table 7. For these patent data results, we only report data for respondents who had been named as an inventor on at least one U.S. patent application at the time of the survey. The results show that foreign-born post-docs applied for an annual average of 0.91 more patents than U.S-born post-docs. Interestingly, this was the only productivity variable that showed significant differences across U.S.-born and foreign-born post-docs.

After removing scientists who are currently post-docs from the analysis, we see that foreign-born scientists are more productive than U.S.-born scientists for all reported productivity measures. In particular, foreign-born scientists published an average of 0.45 more articles per year than U.S.-born scientists - and they presented 0.64 more conference papers each year than their U.S.-born peers. Likewise, the foreign-born scientists were more likely to have applied for a U.S. patent, been granted a U.S. patent, or generated a patent that turned into a commercialized product.

Recent literature suggests that productivity can be affected by the number of hours spent in activities related to research and teaching (Hattie and Marsh 1996). To test this relationship with the 2001 NSF SDR data, we conducted Chi square tests to determine whether foreign-born and U.S.-born scientists differed significantly in the amount of time spent on research and teaching. The results presented in Table 8 show that post-docs (both foreign-born and U.S.-born) are more likely to count research as a primary activity. This is not surprising given the research oriented nature of most science and engineering post-doc positions. Given this result, we wanted to also compare primary and secondary work activities for foreign-born and U.S.-born scientists who

TABLE 8. Comparison of Primary and Secondary Work Activities for Foreign-born Scientists and Native-Born Scientists

	U.S.-Born Scientists		Foreign Born Scientists	
Work Activity	Percent for Post-Docs (N = 8,760)	Percent for Non-Post-Docs (N = 112,731)	Percent for Post-Docs (N = 6,531)	Percent for Non-Post-Docs (N = 30,347)
Primary Activity: R&D	91.9	37.7	92.1	50.9
Primary Activity: Teaching	3.2	43.6	1.0	35.2
Secondary Activity: R&D	48.3	40.6	53.8	45.5
Secondary Activity: Teaching	6.8	22.4	10.3	27.6

Comparisons across post-docs for foreign-born and U.S.-born scientists are statistically significant at the 0.05 level (using Chi-Square test) except for "Primary Activity: R&D.".
All comparisons across non-post-docs for foreign-born and U.S.-born scientists are statistically significant at the 0.05 level (using Chi-Square test).

were not post-docs. Interestingly, among those who did not have post-doc positions, the foreign-born scientists were significantly more likely to have a job where R&D was their primary work activity (50.9 percent compared with 37.7 percent for U.S.-born).

Some scholars have shown that the amount of time spent on research is inversely related to the amount of time spent on teaching (which makes sense because research and teaching are activities that most faculty members are expected to engage in). Among those not in post-doctoral positions, approximately 43.6 percent of the U.S.-born scientists reported teaching as their primary activity compared with 35.2 percent of the foreign-born scientists. Similar trends emerged when we considered secondary work activities. About 28 percent of the foreign-born scientists who were not in post-doc positions counted teaching as their most significant secondary work activity compared with about 22 percent of the U.S.-born scientists. These results confirm our hypotheses about time spent on teaching and research - and paired with the productivity results in Table 7 they relate to findings by earlier studies (Andrews, 1964; Fox 1992; Hattie and Marsh, 1996; Marsh and Hattie, 2002) which showed that productivity is inversely related to time spent on teaching.

Salary

In each of our analyses, foreign-born scientists were more productive than U.S.-born scientists. This includes comparisons across articles, books, conference papers, patents and grants. Therefore, we were interested in whether the foreign-born scientists received higher salaries than U.S.-born scientists when controlling for other work related variables. To do this, we completed two OLS regression analyses using salary as the dependent variable. The results of the model are presented in Table 9.

In Model 1, we explored the relationship between nationality (foreign-born versus U.S. born) and salary, while controlling for gender, Carnegie classification of the employer, year of highest degree, disciplinary field, faculty rank, and primary work activity. This model explained about 40 percent of the variation in salary. In Model 2, we added three additional control variables that served as measures of publication productivity: annual number of articles, annual number of books, annual number of conference paper. The adding of these control variables explained an additional 2.4 percent of the variance in the annualized salary of academic scientists.

In both models, the foreign-born scientists earned significantly lower salaries than their U.S.-born peers when controlling for the above demographic and work related variables. In particular, foreign-born scientists earned about $607 less than the U.S.-born scientists without controlling for publication productivity. Yet, when the three productivity variables were added to the regression analysis, the salary gap increased. According to Model 2, foreign-born scientists are expected to earn about $1188 less than U.S.-born scientists. These results indicate that foreign-born scientists are making less money than their U.S.-born peers - and the difference is even more pronounced when we introduce the higher level of productivity on the part of the foreign-born scientists. For both models the regression coefficients were significant at the 0.05 level, except the discipline of ''Computer & Mathematical Sciences'' in Model 1 and ''Computer Applications'' as ''Primary Work Activity'' in both models. The results from both models reinforce with the findings by Espenshade and colleagues (2001) that foreign-born scientists earned 9.3 percent less than U.S. citizens. However, there are several differences between Espenshade's model and ours, including the fact that Espenshade and colleagues controlled for marital status and English language proficiency levels.

In addition to exploring differences across nationality, we also expected that male scientists would earn more than female scientists.

TABLE 9. Relationship between Salary and Citizenship Status

Independent Variable	Model 1: Unstd. Coefficients	Model 2: Unstd. Coefficients
Constant	63802.3	53530.4
Foreign-Born	−606.5	−1187.6
Male	3681.1	2833.4
Employer is Carnegie Research I or II institution	9670.6	7553.9
Years of Experience	988.3	1129.9
Average Annual Number of Articles Between 1995 and 2001		1997.0
Average Annual Number of Books or Monographs Between 1995 and 2001		3866.1
Average Annual Number of Conference Papers Between 1995 and 2001		626.5
Disciplinary Field (Life & Related Sciences Serves as Reference Group)		
Computer & Mathematical Sciences	−403.8	1324.3
Physical & Related Science	−1843.9	−2397.2
Engineering	10219.2	10448.8
Current Position (Full Professor Serves as Reference Group)		
Associate Professor	−13473.2	−10756.3
Assistant Professor	−16367.4	−12487.6
Instructor	−31850.3	−26259.6
Lecturer	−24905.7	−19748.3
Adjunct	−37180.6	−32431.8
Other Position	−37553.8	−32049.9
Primary Work Activity (Research & Development Serves as Reference Group)		
Teaching	−14925.4	−11432.9
Administration	16498.6	19292.6
Computer Applications	−682.7	622.7
Other	19523.6	21520.1
Adjusted R Square	**0.399**	**0.423**
ANOVA: F Value	**5763.8 ($p < 0.001$)**	**5393.1 ($p < 0.001$)**

All coefficients for both models are significant at the 0.05 level except "Computer & Mathematical Sciences" for Model 1 and "Computer Applications" for Models 1 & 2.
Years of Experience = (2001) - (Year of Highest Degree).
For those with highest degree granted in or before 1995, Annual Number (of articles, books or conferences) = (Total Between 2001 and 1995) / 6 years.
For those with highest degree granted after 1995, Annual Number (of articles, books or conferences) = (Total Between 2001 and 1995) / (2001-Year of Highest Degree).

This hypothesis was confirmed by both models with female scientists earning $3,681 and $2,833 less per year than male scientists in Model 1 and Model 2, respectively. In our regression analyses, we also found significant differences in salary across disciplinary field, and primary work activity. Engineering faculty had the highest salaries in both models, followed by Computer/Math Scientists, Life Scientists, and, lastly, Physical Scientists.

As might be expected, there was a direct relationship between years of experience and salary. Salary also varied according to primary work activity, with Administrators making the highest salaries, followed by those in Computer Applications, R&D and (lastly) Teaching. Not surprisingly, scientists working at Carnegie Research I or II institutions earned higher salaries than scientists at other institutions. Many of these results confirm the findings by Toutkoushian and Conley (2005), who explained the salary gap among faculty by using gender, experience of faculty, educational attainment, discipline, rank, and institution type as predictor variables.

DISCUSSION AND CONCLUSIONS

The purpose of this paper has been to explore the differences in the career trajectories, work satisfaction levels, productivity, and salary of foreign-born scientists and U.S.-born scientists. With the changing demographics of U.S. academic departments, it is becoming more important for university administrators to recruit and retain successful foreign-born scientists. In this section, we briefly summarize our findings and discuss their importance for the recruitment, training, and retention of foreign-born scientists.

Interestingly, both cohorts of foreign-born scientists were more likely than their U.S.-born peers to be employed by a Carnegie Research I or II institution. Taken together, these sets of results indicate that foreign-born scientists are being hired by research-oriented universities at a rate comparable to (or higher than) that of U.S.-born scientists, but younger, foreign-born scientists are more likely to be stuck in lower-ranking, temporary positions. This is a positive finding for the recruitment and retention of foreign-born faculty at research intensive universities.

Without controlling for any other variables, foreign-born scientists made (on average) $6,791 less per year than U.S.-born scientists (with U.S.-born scientists and foreign-born scientists averaging $74,388 per year and $67,597 per year, respectively). This difference was significant at the 0.01 level using a t-test. After controlling for gender, Carnegie classification of institution, year of highest degree, disciplinary field,

faculty rank, and primary work activity, foreign-born scientists earned $607 less per year than U.S.-born scientists. When we controlled also for publication productivity, the salary gap widened, with foreign-born scientists earning about $1,188 less than U.S.-born scientists.

Foreign-born scientists also have lower levels of work satisfaction. For those who were not in post-doc positions (which represents 90 percent of the sample), foreign-born scientists were less satisfied than U.S.-born scientists for all nine variable measures of work satisfaction (including advancement opportunities, job benefits, intellectual challenge, independence, location, level of responsibility, salary, job security, and contribution to society). The areas in which the foreign-born scientists lagged the most behind U.S.-born scientists were in level of satisfaction with salary, level of responsibility, job security, and intellectual challenge. Given the lower level of pay that the foreign-born scientists in our sample received - and the lower ranking positions that they ended up in - these results are not surprising.

The data from our study suggest that foreign-born scientists are more likely than U.S.-born faculty to be in post-doctoral positions at U.S. universities. In addition, they are more likely to have taken that position because other employment opportunities are not available. Before dividing the sample into two cohort groups based on year of highest degree, it appeared that the foreign-born scientists were more likely than U.S.-born scientists to have lower-level faculty positions. Yet, after analyzing early-to-mid career scientists separately from the mid-to-late career scientists, we found that this was more likely for early stage scientists and less likely for the mid-to-late career scientists. It appears that the discrepancies in faculty rank level out over time for the foreign-born and U.S.-born scientists.

The fact that younger, foreign-born scientists are hired into lower-ranking positions more than U.S.-born scientists does not appear to be due to a lack of productivity on the part of the foreign-born scientists. In fact, our analysis suggests that foreign-born scientists have higher levels of productivity than U.S.-born scientists in all areas measured by the 2001 NSF *Survey of Doctorate Recipients* (including patents, articles, books, and conference papers). Despite this higher level of productivity, foreign-born scientists reported lower levels of work satisfaction and lower salaries than their U.S.-born peers. We believe that this is a key issue related to the retention of foreign-born faculty in academic positions because the combination of higher productivity and lower salaries/satisfaction will likely (over the long term) result in lower retention rates of foreign-born scientists in university positions.

One interesting question that we cannot answer with our current dataset is whether the foreign-born scientists are being discriminated against 1) once they are in their current positions (by lower salaries and fewer promotions) or 2) during the hiring process (making it more difficult for them to get stable ladder-rank academic positions in the first place). Even though we cannot fully answer this question, our data do say something about the career trajectories of the two groups. Our data also show that foreign-born scientists are more likely than U.S.-born scientists to have post-doctoral positions. We also found that foreign-born scientists were more likely to be in these positions because "other employment is not available" (35.1 percent of foreign-born versus 20.1 percent of U.S.-born). U.S.-born scientists were more likely than foreign-born scientists to take a post-doc position for all of the remaining reasons, including: post-doc is expected for career in the field, to work with a specific person, to get additional training in the Ph.D. field, and to get training in an area outside the Ph.D. area.

Future related research with this dataset will include exploring which other faculty-related or institution-related variables might explain additional differences that we found between foreign born and U.S.-born faculty. For example, Toutkoushian and Bellas (2003) have used a logistic regression model to examine how a variety of characteristics affect the satisfaction levels of faculty. In future research we would like to use a similar approach for the 2001 SDR dataset. Another future analysis plan is to use an approach similar to that by Bellas and Toutkoushian (1999). This analysis would include the development of a multivariate regression model to examine how a variety of faculty- and institution-related variables impact research output. In addition, we could use a semi-log salary model for future research.

To follow up on the findings presented here, it would also be interesting to further explore where discrimination against foreign-born scientists is most likely to occur. Given that we have seen a 3.4 percent increase in doctoral degrees in 2004 that is due largely to foreign students, it is likely that in the future some of our most talented scientists and engineers will be foreign-born. The long-term retention of foreign-born faculty is an important goal for universities and colleges because these researchers are significant contributors to the scientific enterprise - and (just as importantly) they can serve as positive role models for foreign students who aspire to join the academia. Since several researchers have shown that work satisfaction is a significant component of faculty retention (Johnsrud and Heck, 1994; Rausch, Ortiz, Douthitt, and Reed, 1989), these results are directly relevant to the recruitment and

retention of foreign-born scientists within academic sciences and engineering.

ACKNOWLEDGMENT

The authors would like to thank Lindsey Gorzalski and Sarah Snyder for their research assistance. The use of National Science Foundation (NSF) data does not imply NSF endorsement of the research methods or conclusions contained in this report.

REFERENCES

Andrews, F. M. (1964). Scientific performance as related to time spent on technical work, teaching, or administration. *Administrative Science Quarterly* 9: 182–193.

Antony, J. S., and Valadez, J. R. (2002). Exploring the satisfaction of part-time college faculty in the United States. *Review of Higher Education* 26(1): 41–56.

Astin, H. S., Antonio, A. L., Cress, C. M., and Astin, A. W. (1997). *Race and Ethnicity in the American Professoriate, 1995–1996*, Higher Education Research Institute, University of California, Los Angeles.

Astin, H. S., and Davis, D. E. (1985). Research productivity across the life and career cycles: facilitators and barriers for women. In: Fox, M. (ed.), *Scholarly Writing and Publishing: Issues, Problems, and Solutions*, Westview Press, Boulder, CO, pp. 147–160.

August, L., and Waltman., J. (2004). Culture, climate, and contribution: Career satisfaction among female faculty. *Research in Higher Education* 45(2): 177–192.

Barbezat, D. A. (2002). History of pay equity studies. *New Directions for Institutional Research* 115: 9–39.

Bellas, M. (1993). Faculty salaries: Still a cost of being female?. *Social Science Quarterly* 74: 62–75.

Bellas, M. L., and Toutkoushian, R. K. (1999). Faculty time allocations and research productivity: gender, race, and family effects. *Review of Higher Education* 22: 367–390.

Bender, K. A., and Heywood. J. S. (2004). Job Satisfaction of the highly educated: The role of gender, academic tenure, and comparison income. In: *Science and Engineering Workforce Project*. National Bureau of Economic Research.

Bentley, J. T., and Adamson., R. (2003). *Gender Differences in the Careers of Academic Scientists and Engineers: A Literature Review*, National Science Foundation, Arlington, VA.

Borjas, G. J. (1994). The economics of immigration. *Journal of Economic Literature* 32: 1667–1717.

Carr, P. L., Ash, A. S., Friedman, R. H., Scaramucci, A., Barnett, R. C., Szalacha, L., Palepu, A., and Moskowitz, M. A. (1998). Relation of family responsibilities and gender to the productivity and career satisfaction of medical faculty. *Annals of Internal Medicine* 129: 532–538.

Clark, S. M., and Corcoran, M. (1986). Perspectives on the professional socialization of women faculty: A case of accumulative advantage. *Journal of Higher Education* 57: 20–43.

Clark, S. M., and Lewis, D. R. (1985). *Faculty vitality and institutional productivity: Critical perspectives for higher education*, Teachers College Press, New York, NY.

Cole, J. R., and Singer, B. (1991). A Theory of limited differences: Explaining the productivity puzzle in science. In: Zuckerman, H., Cole, J. R., and Bruer, J. T. (eds.), *The Outer Circle: Women in the Scientific Community*, Norton and Company, New York, pp. 277–323.

Cole, J. R., and Zuckerman, H. (1984). The productivity puzzle: Persistence and change in patterns of publication among men and women scientists. In: Steinkamp, M. W., Maehr, M. L., Kleiber, D. A., and Nicholls, J. G. (eds.), *Advances in Motivation and Achievement*, JAI Press, Greenwich, CT.

Cole, J. R., and Zuckerman, H. (1987). Marriage, motherhood and research performance in science. *Scientific American* 25: 119–125.

Cole, J. R., and Zuckerman., H. (1991). Marriage, motherhood, and research performance in science. In: Zuckerman, H., Cole, J. R., and Bruer, J. T. (eds.), *The outer circle: Women in the scientific community*, Norton and Company, New York, NY, pp. 157–169.

Corley, E. A. (2005). How do career strategies, gender, and work environment affect faculty productivity levels in university-based science centers?. *Review of Policy Research* 22: 637–655.

Diamond, A. M. (1986). The life-cycle research productivity of mathematicians and scientists. *Journal of Gerontology* 41: 520–525.

Elder, B. (2005). The H-1B visa: Is this the answer to staffing problems?. *Technical Support* 13: 9–12.

Espenshade, T. J., Usdansky, M. L., and Chung, C. Y. (2001). Employment and earnings of foreign-born scientists and engineers. *Population Research and Policy Review* 20: 81–105.

Ferber, M. A., and Green, C. A. (1982). Traditional or reverse sex discrimination? A case study of a large public university. *Industrial and Labor Relations Review* 35: 550–564.

Fox, M. F. (1992). Research, teaching, and publication productivity: Mutuality versus competition in academia. *Sociology of Education* 65: 293–305.

Gappa, J. M. (2000). The new faculty majority: Somewhat satisfied but not eligible for tenure. *New Directions for Institutional Research* 105: 77–86.

Ginther, D. K. (2004). Why women earn less: Economic explanations for gender salary gap in science. *AWIS Magazine* 33: 1–5.

Ginther, D. K., and Hayes, K. J. (1999). Gender differences in salary and promotion in the Humanities. *The American Economic Review* 89: 397–402.

Hagedorn, L. S. (1996). Wage equity and female faculty job satisfaction: The role of wage differentials in a job satisfaction causal model. *Research in Higher Education* 37: 569–598.

Hagedorn, L. S. (2000). Conceptualizing faculty job satisfaction: Components, theories, and outcomes. *New Directions for Institutional Research* 105: 5–20.

Handel, M. J. (2005). Trends in perceived job quality, 1989 to 1998. *Work and Occupations* 32: 66–94.

Hattie, J., and Marsh, H. W. (1996). The relationship between research and teaching: A meta-analysis. *Review of Educational Research* 66: 507–542.

Hoffman, E. P. (1976). Faculty salaries: Is there discrimination by sex, race, and discipline? Additional evidence. *The American Economic Review* 66: 196–198.

Johnsrud, L. K., and Heck, R. H. (1994). A university's faculty: Predicting those who will stay and those who leave. *Journal for Higher Education Management* 10: 71–84.

Kalleberg, A. L. (1977). Work values and job rewards: A theory of job satisfaction. *American Sociological Review* 42: 124–143.

Katz, D. A. (1973). Faculty salaries, promotions, and productivity at a large university. *The American Economic Review* 63: 469–47.

Keith, B., Layne, J. S., Babchuk, N., and Johnson, K. (2002). The context of scientific acheivement: Sex status, organizational environments, and the timing of publication on scholarship outcomes. *Social Forces* 80: 1253–1282.

Laden, B.V., and Hagedorn., L. S. (2000). Job satisfaction among faculty of color in academe: Individual survivors or institutional transformers?. *New Directions for Institutional Research* 105: 57–66.

Lee, D. M. S. (1992). Job challenge, work effort, and job performance of young engineers: A causal analysis. *IEEE Transactions on Engineering Management* 39: 214–226.

Lee, S. (2004). Foreign-born scientists in the United States- Do they perform differently than Native-born scientists? (Doctoral Dissertation, Georgia Institute of Technology). Dissertation and Theses: A&I AAT 3155279.

Levin, S. G., and Stephan, P. E. (1989). Age and research productivity of academic scientists. *Research in Higher Education* 30: 531–549.

Levin, S. G., and Stephan, P. E. (1999). Are the Foreign-born a source of strength for U.S. Science?. *Science* 285: 1213–1214.

Levitan, A. S., and Russ, R. (1992). Personal and institutional characteristics affecting research productivity of academic accountants. *Journal of Education and Business* 67: 335–341.

Liebert, R. J. (1977). Research-Grant getting and productivity among scholars: Recent national patterns of competition and favor. *Journal of Higher Education* 48: 164–92.

Lin, C. A. (2004). Are foreign scientists good for the U.S. scientific force?. *Bioscience* 54: 892.

Locke, E. A., Fitzpatrick, W., and White, F. M. (1983). Job satisfaction and role clarity among university and college faculty. *Review of Higher Education* 6: 343–363.

Loeb, J. W., Ferber, M. A., and Lowry, H. M. (1978). The effectiveness of affirmative action for women. *Journal of Higher Education* 49: 218–230.

Long, J. S. (1978). Productivity and academic position in the scientific career. *American Sociological Review* 43: 889–908.

Long, J. S., Allison, P. D., and McGinnis, R. (1979). Entrance into the academic career. *American Sociological Review* 44: 816–830.

Long, J. S., and Fox, M. F. (1995). Scientific careers: Universalism and particularism. *Annual Review of Sociology* 21: 45–71.

Marsh, H. W., and Hattie, J. (2002). The relation between research productivity and teaching effectiveness. Complementary, antagonistic, or independent constructs?. *Journal of Higher Education* 73: 603–641.

Mason, M. A., and Goulden, M. (2004). Marriage and baby blues: Redefining gender equity in the academy. *Annals of the American Academy of Political and Social Science* 596: 86–103.

Meiksins, P. F., and Watson, J. M. (1989). Professional autonomy and organizational constraint. *The Sociological Quarterly* 30: 561–588.

Meltzer, B. N. (1949). The productivity of Social Scientists. *The American Journal of Sociology* 55: 25–29.

Miller-Loessi, K., and Henderson, D. (1997). Changes in American Society: The Context for Academic Couples. In: Ferber, M. A., and Loeb, J. W. (eds.), *Academic Couples*, University of Illinois Press, Champaign, IL, pp. 25–43.

National Science Board. (2003). The science and engineering workforce realizing America's potential. *NSB*, vol. 3: National Science Foundation.

Norris, J. T. 2004. *Restrictions on research awards: Troublesome clauses*. A report to the AAU/COGR Task Force. Association of American Universities, August, 2004.

North, D. S. (1995). *Soothing the establishment The impact of foreign-born scientists and engineers on America*, University Press of America, Inc, Lanham, MD.

Nyquist, J. G., Hitchcock, M. A., and Teherani, A. (2000). Faculty Satisfaction in Academic Medicine. *New Directions for Institutional Research* 105: 33–43.

Olsen, D., Maple, S. A., and Stage, F. K. (1995). Women and minority faculty job satisfaction: Professional role interests, professional satisfactions, and institutional fit. *Journal of Higher Education* 66: 267–293.

Palepu, A., Carr, P. L., Friedman, R. H., Ash, A. S., and Moskowitz, M. A. (2000). Specialty choices, compensation, and career satisfaction of underrepresented minority faculty in academic medicine. *Academic Medicine* 75: 157–160.

Perna, L. W. (2001). Sex and race differences in faculty tenure and promotion. *Research in Higher Education* 42: 541–567.

Rausch, D. K., Ortiz, B. P., Douthitt, R. A., and Reed., L. L. (1989). The academic revolving door: Why do women get caught?. *CUPA Journal* 40: 1–16.

Ropers-Huilman, B. (2000). Aren't you satisfied yet? Women faculty members' interpretations of their academic work. *New Directions for Institutional Research* 105: 21–32.

Smallwood, S. (2005). Doctoral degrees rose 3.4% in 2004, survey finds. The Chronicle of Higher Education, December 9, 2005.

Sonnert, G. with the assistance of Holton, G. (1995). Gender differences in science careers: The Project Access study, Rutgers University Press, New Brunswick, N.J.

Stack, S. (2004). Gender, children and research productivity. *Research in Higher Education* 45: 891–920.

Stephan, P. E., and Levin, S. G. (2001). Exceptional contributions to US science by the foreign-born and foreign-educated. *Population Research and Policy Review* 20: 59–79.

Stephan, P. E., Sumell, A. J., Black, G. C., and Adams, J. D. (2004). Doctoral education and economic development: The flow of new Ph.D.s to industry. *Economic Development Quarterly* 18:151–167.

Strathman, J. G. (2000). Consistent estimation of faculty rank effects in academic salary models. *Research in Higher Education* 41: 237–250.

Toutkoushian, R. K. (1998). Racial and marital status differences in faculty pay. *Journal of Higher Education* 69: 513–541.

Toutkoushian, R. K., and Bellas, M. L. (2003). The effects of part-time employment and gender on faculty earnings and satisfaction. *Journal of Higher Education* 74: 172–195.

Toutkoushian, R. K., and Conley, V. M. (2005). Progress for women in academe, yet inequities persist: Evidence from NSOPF: 99. *Research in Higher Education* 46: 1–28.

Tuckman, B. H., and Tuckman, H. P. (1976). The structure of salaries at American universities. *Journal of Higher Education* 47: 51–64.

Turner, C. S. V. (2002). Women of color in academe: Living with multiple marginality. *Journal of Higher Education* 73: 74–93.

Wanner, R. A., Lewis, L. S., and Gregorio, D. I. (1981). Research productivity in academia: A comparative study of the sciences, social sciences and humanities. *Sociology of Education* 54: 238–253.

Ward, M. E., and Sloane, P. J. (2000). Non-pecuniary advantages versus pecuniary disadvantages: Job satisfaction among male and female in Scottish universities. *Scottish Journal of Political Economy* 47: 273–303.

Watson, J. M., and Meiksins, P. F. (1991). What do engineers want? Work values, job rewards, and job satisfaction. *Science, Technology, & Human Values* 16: 140–172.

Xie, Y., and Shauman, K. A. (1998). Sex differences in research productivity:New evidence about an old puzzle. *American Sociological Review* 63: 847–870.

Zuckerman, H. (1991). The Careers of Men and Women Scientists: A Review of Current Research. In: Zuckerman, H., Cole, J. R., and Bruer, J. T. (eds.), *The Outer Circle: Women in the Scientific Community*, Norton and Company, New York, NY, pp. 27–56.

Received June 3, 2006; accepted January 3, 2007