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Patenting and Invention Activity of U.S. Scientists and Engineers in the Academic Sector: Comparisons with Industry

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ABSTRACT

Analyses have been performed of the patenting and invention activity of U.S. scientists and engineers (S&Es) in the academic sector and comparisons have been made with their counterparts in industry. The analyses are based upon National Science Foundation (NSF) survey questions concerning patent applications, grant awards and commercialization outcomes from the 1995 Survey of Doctoral Recipients and the 1995 National Survey of College Graduates. Patent activity is examined by employment sector, by educational field, by demographic variables, by status and location of university faculty, by technological area, and by selected S&E job characteristics. A series of new indicators -- patent activity rates, patent activity shares and patent success rates -- has been defined and utilized to evaluate the patent involvement and productivity of scientists and engineers in universities and industry. It is recommended that NSF collect data on patenting activity, including commercialization of patent outputs, in its national surveys of the S&E workforce no less frequently than every four years. Data should also be collected on collaboration in patent activity between academic and industrial S&Es in the U.S., and between U.S. S&Es and their counterparts in other countries.

INTRODUCTION.

Patenting and invention activity represents a growing element of U.S. university involvement in technology transfer. In 1998, 3,151 U.S. patents were awarded to U.S. universities compared with just 464 patents in 1982. Whereas two decades ago, academic patents constituted less than one-half of one percent of all new awards of patents of U.S. origin, they now make up almost five percent of these new awards. Thus, academic patents, spurred on in part by the Bayh-Dole Act of 1980 and increased university-industry interaction, are growing much faster than all U.S. patent awards, albeit starting at a much lower level (Science and Engineering Indicators 2000, forthcoming).

This paper presents and analyzes data from representative national surveys conducted by the National Science Foundation (NSF) in 1995 concerning patenting and licensing activity of U.S. scientists and engineers (S&Es). Special emphasis is given to those employed in academic institutions, and contrasts are drawn with scientists and engineers in industry. The survey data are available through the NSF's Scientists and Engineers Statistical Data System, or SESTAT. (National Science Foundation, 1999)[2].

The first survey patent question was: "Since April 1990, have you been named as an inventor on any application for a U.S. patent?" If the answer to this question (hereafter referred to as the Key Question) was Yes, survey participants were asked three questions we refer to as the Follow-Up Questions: "Since 1990... 1. How many applications for U.S. patents have named you as inventor?" 2. "How many patents have been granted to you as an inventor?" 3. "How many of the patents recorded as GRANTED (recorded in category 2 above) have resulted in commercialized products or processes or have been licensed?" To date, the year 1995 was the

Figure 1
Definitions for Patenting Activity Statistics

Definitions Involving Numbers of Individuals

Applicants: the number of S&Es who were named as inventors on at least one patent application during the five-year period from April 1990 to April 1995

Grantees: the number of S&Es who were granted at least one patent as inventors during the five-year period from April 1990 to April 1995

Commercializers: the number of S&E whose granted patents have resulted in at least one commercialized product, process or license during the five- year period from April 1990 to April 1995

Patent Activity Rate: the percentage of S&Es in a given group who were named as inventors on at least one patent application during the five-year period from April 1990 to April 1995

Patent Activity Share: among those S&Es who were named as inventors on at least one patent application during the five-year period from April 1990 to April 1995, the percentage represented by a specific sub-group

Grant Activity Share: among those S&Es who were granted at least one patent as inventors during the five-year period from April 1990 to April1995, the percentage represented by a specific sub-group

Commercialization Activity Share: among those S&Es whose granted patents have resulted in at least one commercialized product, process or license during the five-year period from April 1990 to April 1995, the percentage represented by a specific sub-group

Definitions Describing Patenting Rates Based on Individuals

Applicant's Grant Success Rate: the ratio of grantees to applicants times 100

Grantee's Commercialization Success Rate: the ratio of commercializers to grantees times 100

Overall Commercializer's Success Rate: the ratio of commercializers to applicants times 100

Ratios of Numbers of Patents to Numbers of Individuals

Average Number of Applications: ratio of the total number of patents applied for by applicants to the total number of applicants

Average Number of Grants: ratio of total number of patents granted to grantees to the total number of grantees

Average Number of Commercialized Products, Processes or Licenses: ratio of total number commercialized products, processes or licenses identified by commercializers to the total number of commercializers

Definitions Describing the Numbers of Patents

Patents Applied For: the total number of patents applied for by applicants during the five-year period from April 1990 to April 1995

Patents Granted: the total number of patents granted to applicants during the five-year period from April 1990 to April 1995

Patents Commercialized: the total number of patents granted to grantees that resulted in at least one commercialized product, process or license during the five-year period from April 1990 to April 1995

Definitions Describing Patenting Rates Based on the Number of Patents

Patent Grant Success Rate: ratio of patents granted to patents applied for times 100

Patent Commercialization Success Rate: ratio of patents commercialized to patents granted times 100

Overall Patent Success Rate: ratio of patents commercialized to patents applied for times 100

only year that these patent questions were asked in NSF surveys. Figure 1 summarizes definitions utilized in presenting and analyzing the results.

PATENT ACTIVITY BY EMPLOYMENT SECTOR AND EDUCATIONAL FIELD

Results from the integrated SESTAT surveys[3] indicate that 204,700 scientists and engineers, 8.0% of those who were eligible to respond, were named as inventors on at least one patent application over a five-year period since April, 1990. The corresponding patent activity rate for the Education Sector (4.6%) was less than half that of the Industry Sector (10.0%)[4]. Of those indicating such patent activity, 83.5% were in industry while the patent activity share in education was 12.1%. For all employment sectors (including government), the largest single contributor to patent activity by highest degree type was S&Es with bachelor's degrees as their highest degrees, 40.1%, with doctorates in second place (33.7%.)

The patent activity rate for S&E doctorate holders in all employment sectors was 12.1%.[5] In industry, more than one in five doctorates (20.8%) were named as inventors on patent applications during the five-year period since April, 1990, more than three times the patent activity rate for doctorates in education (6.0%). In the Education Sector, 69.2% of those with patent activity have doctorates and almost all of these work in institutions of higher education. Those in higher education whose highest degrees are bachelor's or master's degrees constitute about 22% of all those with patent activity, a relatively small but nevertheless substantial percentage for those in universities without doctorates.[6] By contrast, in industry, a large majority of those with patent activity possessed highest degrees that were below the doctorate; 44.6% had bachelor's degrees and 26.2% had master's degrees.

In the Education Sector, engineering was the field of highest degree of scientists and engineers with the largest patent activity rate (13.4%), followed by the physical sciences (6.8%)

and the life sciences (5.4%).[7] S&Es whose highest degrees were in the life sciences had the greatest share of patent activity, namely 29.7% of the total, closely followed by engineers with 28.9%. By contrast, in industry, highest degree-holders in the physical sciences had the largest patent activity rate (20.0%) followed by engineers (13.7%) and life scientists (10.2%). Over one-half (52.0%) of all S&Es in industry active in patenting had their highest degrees in engineering, reflecting in part their relatively large total population in industry. However, engineers in both industry and education were more active in patenting than their numbers would indicate.

More details of patenting activity of doctoral scientists and engineers at institutions of higher education emerge from the 1995 Survey of Doctoral Recipients (SDR). University research institutes (11.7%) and medical schools (10.3%) had the highest patent activity rates for S&Es with doctoral degrees, higher than for four-year colleges and universities (4.9%). However, more than half of this activity (54%) took place at the four-year colleges and universities. Faculty rank had a modest effect on patent activity, with full professors having slightly higher rates (6.8%) than did their more junior colleagues (associate professors = 5.4%; assistant professors = 5.3%). However, outside of these three traditional professorial rank categories, patent activity rates were higher and a significant share (28%) of patent activity took place. A related result is that those reporting that they have tenure have slightly lower patent activity rates (5.8%) than those indicating they do not (6.9%), in apparent contradiction to the results by faculty professorial rank.[8]

In the Education Sector, the highest patent activity rates were in the Pacific and New England Regions followed by the Mountain Region. The East South Central Region had the lowest patent activity rate. The Pacific, New England and Mountain Regions were the only regions in which doctorate holders had patent activity rates above their proportion in the

population. Foreign-earned doctorates in the academic sector with patent activity tended to be more concentrated in the New England Region. Some 26% of all patent activity by doctorates in industry took place in the Middle Atlantic States compared with 14% for the academic sector.

SOME DEMOGRAPHIC RESULTS

Gender. Females with patent activity were found more often to have their highest degree in the life sciences and less often in engineering than their male counterparts, with the tilt being more pronounced in the academic sector than in industry. This could very well be an important factor in the lower patent activity rates for females. In education, females comprised 25% of the doctorate-holding population but were only 11% of the patent activity share. The patent activity rate for males, 7.1%, in the Education Sector was more than two and one-half times that for females (2.7%). These indicators of higher male patent activity were also found in industry. Within the academic sector, overall for all highest-degree levels, 43.4% of females with patent activity earned their highest degree in the life sciences and only 7.9% in engineering; for males, engineering had the largest percentage, 31.8% with the life sciences second with 27.8%. Within industry, engineering was the field of highest degree of 32.5% of females with patent activity, slightly larger than for life sciences (28.4%), and the field of over half (53.8%) of males with patent activity.

Citizenship. For doctorate holders in educational institutions, the patent activity rate for U.S. citizens, 5.8%, was somewhat less than for non-U.S. citizens (7.4%). This difference is smaller than for the overall patent activity rates for all highest degree types in all employment sectors (7.8% for citizens vs. 11.6% for non-citizens). For doctorates in industry, the gap widens to 9.7% for citizens vs. 15.8% for non-citizens. It should be noted that the racial/ethnic group

with the highest patent activity rates, Asians (see below), consisted of more than one-half (51.6%) naturalized citizens and 21.3% of non-U.S. citizens who are permanent residents.

Race/Ethnicity. The patent activity rate for Asian S&Es with doctorates in the educational sector was 8.3%, compared with 5.8% for whites and 4.2% for under-represented minorities. The same order persists for doctorate holders in industry (Asian: 26.6%; white: 20.0%; under-represented minorities: 14.0%.) and overall for S&Es of all highest degree levels in all employment sectors (Asian: 9.7%; white: 8.2%; under-represented minorities: 3.8%).

Persons With Disabilities.[9] The patent activity rate of those with disabilities was 6.0% compared with 8.1% for those without disabilities. This pattern of somewhat higher patent activity rates for those without disabilities holds for both the education and industry sectors.

Age. Examination of patent activity rates within age groups reveals that although the patent activity of S&Es in industry tends to fall off somewhat for older S&Es, the opposite seems to be true in the education sector. The patent activity rate for S&Es in education between the ages of 65 and 75 is 8.1%, higher than any other previous five-year age interval and well above the patent activity rate in education of S&Es of all ages (4.6%).

TECHNOLOGICAL AREAS

Table 1 summarizes information about patent activity of S&Es in the Education and Industry Sectors who also indicated that they were working during a typical week in one or more of seven technological areas The patent activity share of S&Es working in biotechnology in the Education Sector was 41.8%, a considerably larger share than that for the next largest technological area, sensor and signal processing at 23.2%. If patent activity shares for the Education Sector are compared with those for industry, there are marked differences. Biotechnology for industry slips to fifth out of seven. Advanced materials heads the industry

list, followed by micro- and opto-electronics/semiconductor devices and sensors and signal processing. Thus the strong emphasis on patent activity in biotechnology in the Education Sector is not reflected in the Industry Sector results.

Table 1
Patent Activity Rates and Patent Activity Shares For Individuals Working in the Selected Technological Areas by Employment Sector, 1995

Technological Area	Education Sector			Business/Industry Sector		
	No. of S&Es working in this area	Patent Activity Rate, %	Patent Activity Share,%	No. of S&Es working in this area	Patent Activity Rate, %	Patent Activity Share,%
Flexible manufacturing, robotics	1,400	11.6	5.7	17,800	14.4	10.4
Advanced materials	5,400	13.3	21.9	49,600	25.2	29.0
Biotechnology	10,400	11.0	41.8	21,900	18.5	12.8
Micro or opto-electronics, Semiconductor devices	4,200	12.5	16.8	46,200	20.6	27.0
High performance computing	3,800	4.9	15.2	37,000	10.1	21.7
Software producibility	2,400	4.6	9.4	25,400	7.0	14.9
Sensor and signal processing	5,800	13.0	23.2	42,300	16.8	24.7

The patent activity rate describes the percentage of S&Es who have been named as inventors on at least one patent application from April 1990 to April 1995 and are working in the specified technological area. Of all S&Es working in the seven technological areas who have been named as inventors on at least on patent application from April 1990 to April 1995, the patent activity share is the percentage working in the specified technological area.

Notes: Numbers have been rounded to the nearest hundred. Percentage totals do not add to 100% because multiple responses were allowed.
Source: National Science Foundation/Division of Science Resources Studies, 1995 SESTAT (Scientists and Engineers Statistical Data System)

SOME RELATIONSHIPS BETWEEN PATENTING AND OTHER VARIABLES.

Participation in R&D. U. S. Government Support. In both universities and industry, as might be expected, those involved in R&D had higher patent activity rates than those not involved in R&D (Kruytbosch, 1997). However, a strong and unexpected finding is the negative relationship between U. S. government support and patent activity rate among industrially employed doctoral S&Es in R&D (rate with government support = 20.2%; without = 34.8%). This finding may be due to the complexities of contracting with industry in the defense sector. Moreover, perhaps industry is more likely to patent-protect work supported with its own money as opposed to work supported with government funds. By contrast, in the Education Sector,

those doctoral S&Es in R&D with government support had patent activity rates almost three times (11.9%) that of their counterparts without government support (4.2%).

Second Jobs. In the Education Sector, the patent activity rate was somewhat higher for those with second jobs (5.7%) than for those without (4.3%). By contrast, in the Industry Sector, the patent activity rate was lower for those with second jobs (8.7%) than for those without (10.2%). Perhaps the second job activity of academics -- consulting, involvement in start-up and spin-off companies, etc. -- fosters their involvement in patent activity whereas industrial S&Es patent mainly as an integral part of their principal jobs (National Science Foundation, 2000).

Salary; Average Number of Hours Worked. S&Es who were active in patenting earned more money both on their principal jobs and from all sources than those who were not active. However, the dollar gap between those with and without patent activity was somewhat larger in the Education Sector than in the Industry Sector, indicating that on average, there was more of a premium earned outside of their principal jobs by those S&Es in the Education Sector who patent than by those in industry. In the Education Sector, those active in patenting worked on average 51 hours per week at their principal job compared with 45 hours for those who were not; the gap is smaller in industry.

Relationship of Job to Educational Field. In the Education Sector, there does not appear to be a relationship between the patent activity rate on one hand, and the perceived closeness of jobs held by S&Es to their highest degree on the other. However, in the Industry Sector, the patent activity rate increased if their principal jobs were seen as more closely related to their highest degrees. The patent activity rate was more than twice that if they were closely related than if they were not related (closely related: 11.6%; somewhat related: 9.2%; not related: 5.2%).

PATENT GRANTS AND COMMERCIALIZATION: THE FOLLOW-UP QUESTION RESULTS

Education Sector vs. Industry Sector. It can be seen from Table 2 that the conversion of patent applications to grants and to commercialized products proceeds with somewhat higher success rates in industry than in the Education Sector. On average, slightly more than one in five patents applied for in education resulted in a commercialized product, process or license compared with about three in ten in industry. Also, the average number of patents applied for in education by scientists and engineers was about one less than in industry. However, the patent grant success rate was slightly higher in education than in industry. [10]

In the Education Sector, 41% of S&Es named as inventors on at least one patent application in the five years since April,1990 also received at least one patent grant during the same period. Furthermore, more than one-quarter (27%) of the S&Es in the Education Sector who submitted at least one patent application in the five years since April, 1990 also reported that these patent applications resulted in at least one commercialized product or process or was licensed during the same period. This latter indication of practical yield is somewhat less in education than for industry (46%) but respectable nevertheless.

Gender. It can also be seen from Table 2 that the overall commercializer's success rate was smaller for females than for males in both the education sector and the industry sector. In addition, there was a relatively high average number of patents applied for and of patents granted to males in industry. However, the overall patent success rate was higher for females than for males in the Education Sector but not in industry, the difference in education resulting from a higher average number of commercialized products, processes or licenses for females. This latter result is subject to some uncertainty because of the small number of female commercializers.

Within the Education Sector, the female patent activity share dropped from 12.0% for applications to 11.6% for grants to 10.7% for commercialization. Within the Industry Sector, the share fell from 8.3% to 6.9% to 6.2%, respectively. Thus, the female patent activity share tends to become smaller as one moves from the application to the commercialization stage.

Table 2
Summary Results of Patent Follow-up Questions for the Education and Industry Sectors

Patent Activity Statistic	Education Sector			Business/Industry Sector		
	TOTAL	Female	Male	TOTAL	Female	Male
No. of Applicants	24,800	3,000	21,800	170,800	14,200	156,600
No. of Grantees	16,200	1,900	14,400	117,500	8,100	109,500
No. of Commercializers	6,600	700	5,900	78,500	4,900	73,700
Applicant's Grant Success Rate, %	65.6	63.2	66.0	68.8	56.9	69.9
Grantee's Commercialization Success Rate, %	40.9	37.8	41.3	66.8	60.2	67.3
Overall Commercializer's Success Rate, %	26.8	23.9	27.2	46.0	34.2	47.1
Average No. of Applications	2.18	1.71	2.24	3.16	2.30	3.24
Average No. of Grants	2.14	1.66	2.21	2.84	1.88	2.91
Average No. of Commercialized Products, Processes or Licenses	1.76	2.26	1.70	2.07	1.59	2.11
Patents Applied For	53,900	5,100	48,900	540,400	32,800	507,600
Patents Granted	34,800	3,100	31,700	333,400	15,200	318,200
Patents Commercialized	11,700	1,600	10,100	163,000	7,700	155,200
Patent Grant Success Rate, %	64.6	61.5	64.9	61.7	46.4	62.7
Patent Commercialization Success Rate, %	33.5	51.4	31.7	48.9	50.9	48.8
Overall Patent Success Rate, %	21.6	31.6	20.6	30.2	23.6	30.6

Notes: Numbers have been rounded to the nearest 100. Totals may not add due to rounding.
Source: National Science Foundation/Division of Science Resources Studies, 1995 SESTAT (Scientists and Engineers Statistical Data System)

Educational Field. Table 3 summarizes success rates and average numbers of patents in the Education Sector for S&Es from three educational fields of highest degree. There is relatively little difference in the overall commercializer's success rate among engineering, physical sciences and life sciences highest degree-holders. However, when the average number of patents is taken into account, the overall patent success rate for the physical sciences (27.0%)

was higher than for engineering (21.9%) and the life sciences (18.5%). In the Industry Sector, the overall commercializer's success rate was considerably larger than in the Education Sector for those with highest degrees in engineering and the physical sciences and about the same in the life sciences. By contrast, the overall patent success rate was about the same in the two sectors for the physical and life sciences but the rate in industry for engineering highest degree-holders was higher than in education.

Citizenship. In education, whereas non-citizens have a larger average number of patent applications (2.65) and especially of grants (3.35), than U.S. citizens (2.11 applications; 1.97 grants), the average number of patents commercialized is about the same for citizens and non-citizens. In industry, a somewhat similar effect emerges in which non-citizens average a higher number of patent applications but fewer commercialized. In the education sector, a very high patent grant success rate for non-citizens was compensated by a low commercialization success rate such that in the end, citizens had a higher overall patent success rate than non-citizens. In industry, success rates for citizens were higher at all stages of the patenting process. However, in both education and industry, the non-citizen share of patent activity throughout the patenting process was somewhat larger than the non-citizen share of S&Es responding yes or no to the Key Question.

Race/Ethnicity. In the Education Sector, the average number of patents applied for and granted was higher for whites (2.28-2.24) than for Asians (1.71-1.67) or under-represented minorities(1.80-1.73). The average number commercialized was higher for whites (1.80) than for Asians (1.63); results for under-represented minorities in education are unavailable due to too few responses. However, the overall patent success rate was higher for Asians (26.7%) than for

Table 3

Patent Activity Statistics by Employment Sector and Field of Highest Degree

Patent Activity Statistic	Education Sector			Business/Industry Sector		
	Life Sciences	Physical Sciences	Engineering	Life Sciences	Physical Sciences	Engineering
Applicant's Grant Success Rate, %	62.8	68.2	71.5	56.2	75.8	70.5
Grantee's Commercialization Success Rate, %	45.4	40.8	42.2	52.8	62.4	68.9
Overall Commercializer's Success Rate, %	28.5	27.8	30.2	29.6	47.3	48.6
Average No. of Applications	2.23	2.39	2.26	2.82	4.12	3.00
Average No. of Grants	2.05	2.55	2.21	2.45	4.05	2.60
Average No. of Commercialized Products, Processes or Licenses	1.44	2.32	1.64	1.86	2.25	2.13
Patent Grant Success Rate, %	57.9	72.8	70.1	48.8	74.4	61.1
Patent Commercialization Success Rate, %	31.9	37.1	31.3	40.2	34.6	56.5
Overall Patent Success Rate, %	18.5	27.0	21.9	19.6	25.8	34.5

Source: National Science Foundation/Division of Science Resources Studies, 1995 SESTAT (Scientists and Engineers Statistical Data System)

whites (21.4%). In industry, the average number of patents applied for by Asians was higher than that for whites but the average number of patents commercialized was lower. The patent activity share among whites, Asians and under-represented minorities did not vary much as one moves from applications to grants in both the Education and the Industry sectors. However. Asians had a larger share (12.8-14.3%) and under-represented minorities a smaller share (2.3-3.0%) of patent activity in industry compared with their respective shares of the total population answering Yes or No to the Key Question.

Age. Patenting success rates for individual S&Es 55 years of age and older were higher than for those less than 55 years of age in both the Education and Industry Sectors. The overall commercializer's success rate in education for the more senior of the two age groups was 37% compared with 24% for their younger colleagues. In both the education and industry sectors, the patent activity share of the 55 and older group exceeded that of the total relevant population from

application through to commercial outputs. The excess is particularly notable in the Education Sector, where the 55 and older cohort accounts for 31.1% of the patent grants and 32.3% of the commercialized outputs, while representing only 15.0% of the total population.

CONCLUSIONS AND RECOMMENDATIONS

Although a large percentage of patent activity by scientists and engineers in the U.S., as might be expected, occurs in industry, it is clear that university personnel are involved to a considerable extent. In academe, more than two in five of the S&Es named as inventors on at least one patent application in the five years since April, 1990 also received at least one patent grant during the same period. Furthermore, more than one-quarter of the S&Es in the academic sector who submitted at least one patent application in the five years since April, 1990 also reported that these patent applications resulted in at least one commercialized product or process or was licensed during the same period. Biotechnology received the most attention in universities whereas in industry, patent activity was more broadly distributed across technological areas. Although smaller than the overall patent success rate for industry, it is clear that a significant fraction of patent activity in universities results in commercialized outputs, thus adding to the body of evidence pointing to the increasing role being assumed by universities in commercially relevant work (Morgan and Strickland; Grossman, Reid and Morgan).

Though not predominant, a substantial amount of patent activity takes place in universities involving scientists and engineers who are not in the traditional professorial ranks and/or who are not doctoral degree holders. These S&Es include research associates, post-doctoral research associates, students and other non-tenure track, non-faculty appointments. Future surveys might give more attention to these individuals.

Another interesting result is that older scientists and engineers in academia report equivalent or greater patent productivity, as measured by patent activity rates, than younger S&Es. Particularly striking is that, although subject to some uncertainty, the patent activity rate for academic S&Es between 65 and 75 years of age is greater than for their colleagues in younger age cohorts. Thus, the graying of the faculty combined with elimination of a mandatory retirement age for tenured faculty may in fact be having a positive effect on patent productivity.

Although female S&Es were found to have smaller patent activity rates than males in both the Education and Industry Sectors, female S&Es are more likely to have their highest degrees in fields with lower patenting activity rates (such as the life sciences) than males. Non-citizens in the Education and Industry Sectors have higher patent activity rates than U.S. citizens but are less likely to see their inventions commercialized. Asian S&Es in universities and industry have higher patent activity rates and under-represented minorities have lower rates when each are compared to whites. S&Es without disabilities have a somewhat higher patent activity rate than those with disabilities in both sectors. Further analysis of these differences is needed; they may be only partly explainable by differences in educational field.

Academic involvement in industry-oriented research and patenting is growing rapidly. Therefore, we recommend that NSF collect data on patenting activity, including information on commercialization of patents and the resulting products, processes and licenses, in its national surveys of the scientific and engineering workforce no less frequently than every four years. Data collected should be expanded to obtain information on collaboration in patenting between academic and industrial scientists and engineers in the U.S. In addition, given the growing importance of globalization and of international scientific and technological collaboration, we

recommend that data be collected on collaboration in patenting activity between U.S. scientists and engineers and their counterparts in other countries.

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NOTES.

[1] One of us (Morgan) participated in this research while he was an American Educational Research Association Fellow in the Division of Science Resources Studies at the National Science Foundation.

[2] SESTAT combines results from three surveys, the Survey of Doctoral Recipients (SDR), the National Survey of College Graduates (NSCG), and the National Survey of Recent College Graduates (NSRCG).

[3] The total 1995 weighted SESTAT population is 12,036,200 scientists and engineers. This population includes individuals who have a bachelor's degree or higher in science or engineering, or who are working in a science or engineering occupation, or both. All employed scientists and engineers in the SDR were asked the patent questions. However, only those employed scientists and engineers in the NSCG who indicated that they spent ten percent or more of their principal work activity time in a typical workweek in applied research, basic research, development or design were asked these questions. The net result is that only 2,561,400 scientists and engineers, or 21.3% of the total SESTAT population responded to the patent questions. Excluded are S&Es who earned doctorates outside of the U.S. since 1990 and those holding bachelors and masters degrees surveyed in the NSRCG. The latter survey did not include the patent questions.

[4] One useful tool for analysis using SESTAT is the three-sector employment summary, in which employed S&Es are grouped into one of three employment sectors: education, government and business/industry. The Education Sector includes primary and secondary schools; 2-year colleges, community colleges, and technical institutes; 4-year colleges and universities, medical schools (including university-affiliated hospitals or medical centers); university-affiliated research institutes; and other educational institutions. The universities and higher educational institutions contain about 95% of the S&Es with patent activity in the Education Sector of the SESTAT data base.

[5] Using doctorates from SESTAT gives results that are not identical with results from the SDR but the two are generally close enough to support comparisons and trends.

[6] About 22% of patent activity in universities is attributable to S&Es whose highest degrees are bachelors or masters degrees, compared with 25% for the SESTAT Education Sector as a whole.

[7] The six major educational field or background (highest degree) categories are as follows: computer and math sciences, life and related sciences, physical and related sciences, social and related sciences, engineering, and non-S&E degrees.

[8] One major factor contributing to the apparent contradiction between the effect of faculty rank versus tenure status on patenting is that associate professors without tenure, who constituted 22% of all associate professors, had patent activity rates more than twice that of associate professors with tenure (9.8% vs. 4.1%). There is evidence that some of these associate professors without tenure as reported in the SDR are not on the tenure track, indicating that the phrase “associate professor” was being used by respondents and/or their institutions in non-traditional ways.

[9] A person with disabilities is one who responded that he or she had a moderate or greater degree of difficulty on at least one of four activities listed in the SDR and NSCG surveys.

[10] The survey questions do no ask if there is more than one inventor named on a patent application or grant. Therefore, the number of patents derived from the follow up questions are subject to some uncertainty. The 1999 U.S. utility patents granted had an average of 2.3 inventors per patent (Hirabayashi, 2000).

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