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MOVEMENT OF STAR SCIENTISTS AND ENGINEERS AND HIGH-TECH FIRM ENTRY

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ABSTRACT

This paper extends the concept of star scientist to all areas of science and technology. We follow careers 1981-2004 for 5,401 stars as identified in ISIHighlyCited.com^{SM}, using their publication history to locate them each year. The number of stars in a U.S. region or in one of the top-25 science and technology countries generally has a consistently significant and quantitatively large positive effect on the probability of firm entry in the same area of science and technology. Other measures of academic knowledge stocks have weaker and less consistent effects. Thus the stars themselves rather than their potentially disembodied discoveries play a key role in the formation or transformation of high-tech industries. We identify separate economic geography effects in poisson regressions for the 179 BEA-defined U.S. regions, but not for the 25 countries analysis. Stars become more concentrated over time, moving from areas with relatively few peers to those with many in their discipline. A special counter-flow operating on the U.S. versus the other 24 countries is the tendency of foreign-born American stars to return to their homeland when it develops sufficient strength in their area of science and technology. In contrast high impact articles and university articles and patents all tend to diffuse, becoming more equally distributed over time.

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In a series of articles, we have provided evidence that for rapidly advancing science and technology areas such as biotechnology, individual "star" scientists making major discoveries play an important role in determining where and when new or previously existing firms begin using the new technologies and which firms are most successful (Zucker and Darby 1996, 2001, 2006b; Zucker Darby and Brewer 1998; Zucker, Darby, and Armstrong 1998, 2002; Darby and Zucker 2001, 2006a). This paper expands on that work in four major ways: First, we focus on the question of whether or not the star scientist has an independent role separate from the discoveries he or she makes. Second, we expand our coverage of science base to all areas covered by the Science Citation Index and our coverage of firms expands to all those for which U.S. patents have been assigned on issue or with which authors of articles are affiliated in the Science Citation Index, 1981-2004. Third, we provide evidence on 25 countries which do most of the world's scientific research and commercial innovation instead of concentrating on one or two countries.[1] Fourth, we validate ISIHighlyCited.com[SM] as an empirically useful means of identifying scientific stars.

We show here that star scientists do have a statistically and substantially significant impact on firm entry even after accounting for such measures of local knowledge stock as high-impact (highly cited) articles except those with firm authors, all publications by university authors except those with firm co-authors, and U.S. patents assigned at issue to universities. Since the embodied knowledge, insight, taste, and energy of the stars plays a role separate from their potentially disembodied discoveries, this evidence strengthens the case for the importance of the work of these extraordinary individuals for the economic development of regions and

nations. Furthermore, while the distribution of knowledge stock measures shows a slight tendency – if anything – toward more evenness over time, the distribution of star scientists becomes significantly more concentrated in the leading centers over time. Counts of non-university patents show a less consistent dependence on the local presence of star scientists.

Section I lays out the analytical approach and hypotheses to be examined. We discuss the data set and estimation methodology in Section II. Our empirical results are reported in the next section. We summarize the results and draw our conclusions in Section IV.

I. Analytical Approach and Hypotheses

As in our prior work we assume that the probability λ that a firm will begin to use a given type of new technology through birth or change in focus in a particular country or region is small for an arbitrarily short period of time, so that entry occurs randomly over time in accordance with the poisson process. While the poisson process is frequently used to characterize the distribution of failures – such as light bulbs burning out – it is useful for characterizing countable events of a positive nature as well. The probability λ is assumed to vary across regions and years according to $\log \lambda = x\beta$ where x is a row vector of the explanatory variables and β is a parameter vector to be estimated.[2] In our previous work the significant explanatory variables have been primarily measures of the knowledge base in the region and of the economic geography (employment and average wage per job as a proxy for education level of the local labor force).

Zucker and Darby (1996) and Zucker, Darby, and Brewer (1998) introduced the concept of biotechnology stars based upon productivity measured by the number of articles written through 1990 which reported a genetic-sequence discovery. Direct involvement of these stars

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proved to be a major factor in determining which firms were ultimately major winners in biotechnology (Zucker, Darby, and Armstrong 1998, 2002; Zucker and Darby 2001). In this paper we operationalize the concept of star scientist and engineers as those 5,401 very productive authors profiled in ISIHighlyCited.com^{SM} across the range of science and engineering topics covered in the Science Citation Index. By including the number of these stars active in a region and year as an explanatory variable, we specifically investigate whether these extraordinary individuals play an independent role in promoting the entry of firms into their area of science and technology when their discoveries are accounted for in measures of the local knowledge stocks of high impact articles, all university articles, and university patenting. Based on our biotechnology work, we hypothesize that they do have a separate positive impact on λ, but acknowledge controversy as to how far beyond biotechnology and other high-science-driven areas that effect will be present.

We hypothesize that a very similar process explains commercial development in the form of non-university patenting, although the corresponding λ would surely be of larger magnitude per unit of time. Since stars mostly work in the university (even stars affiliated with firms most often have a primary appointment with a university), we hypothesize that their effect on non-university patenting is likely to be weaker but still present. Moreover, we believe that it is interesting to quantify the effects of the academic knowledge stocks more generally on regional patenting.

II. Empirical Methodology

Our empirical analysis focuses on entry of firms and non-university patenting over time and by U.S. regions or by countries. The data bases for this study have been substantially enlarged in both size and coverage from those used in any other study of which we are aware. Section II.A describes the data used in the empirical analysis. Section II.B summarizes the standard estimation methodology.

II.A. The Data

The primary source databases for the analysis are the complete, continuously updated and parsed U.S. Patent database of the Zucker-Darby Knowledge, Innovation, and Growth Project and the *Science Citation Index Expanded, Social Sciences Citation Index, Arts & Humanities Citation Index, High Impact Papers,* and *ISI Highly Cited* of the Institute for Scientific Information®, Inc. (ISI®, 2005, 2006). Our patent data cover the 3,891,720 U.S. patents granted by USPTO from 1976 to 2005. The ISI database contains more than 24,250,000 records from over 8700 peer-reviewed scientific journals. Other sources are noted where relevant.

Although our data cover all countries, computational considerations led us to limit our analysis to the 25 top science and engineering countries defined as all countries that accounted for at least 0.5% of all ISI articles or at least 0.1% of all U.S. patents granted, 1976-2004, or both, with articles prorated by authors' addresses and patents prorated by inventors' addresses. These "top-25 science and technology (S&T) countries" are: Australia, Austria, Belgium, Brazil, Canada, China, Denmark, Finland, France, Israel, India, Italy, Japan, Germany, the Netherlands, Norway, Poland, South Korea, Spain, Sweden, Switzerland, Taiwan, the United Kingdom, the United States, and

(counted as the same country) the USSR and Russia. These 25 countries account for 92.8% of all ISI articles and 99.2% of U.S. patents.

These data are used to create two analysis data sets containing data from 1981 through 2004 for each of the 179 U.S. regions and also for each of 25 top science and engineering countries (including the U.S.). These longitudinal (panel) data sets consist of 179 regions x 24 years = 4,296 observations and 25 countries x 24 years = 600 observations, respectively. Some analysis is done with the U.S. deleted from the country data set, leaving 576 observations. The U.S. Bureau of Economic Analysis defines the 179 regions as functional economic areas such that each U.S. county is assigned to a region which includes the major metropolitan center for which commuting, shopping, and newspaper readership predominates (Johnson and Kort 2004). The variables contained in the data sets and their summary statistics are listed in Table 1. Their construction is described immediately below.

The variables in each data set are categorized into six science and technology areas: Biology, Chemistry & Medicine; Computing & Information Technology; Semiconductors, Integrated Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Each organization name appearing in the assignee-at-issue field of a patent is categorized as a firm, a university, or put in a miscellaneous other category which includes governmental organizations and research institutes. If a patent has n assignees, where n ≥ 1, each assignee is assigned 1/n for that patent. Organization names appearing in research address or reprint address fields of ISI articles are similarly grouped. Articles that have reported affiliations in the research address field are assigned to those organizations, with each organization getting 1/m credit for that article, where m is the number of research addresses

reported. Those without a research address are assigned to the organization reported in the reprint address, provided that one exists.

For purposes of locating observations, each valid U.S. address in these fields is assigned to a county and the corresponding region using the Federal Information Processing Standard (FIPS55) database maintained by the U.S. Geological Survey. (http://geonames.usgs.gov/fips55.html). Foreign addresses are grouped based on the country of origin.

II.A.1. Science and Technology Areas

Tushman and Anderson (1986) emphasize the stability in the science and technology base of a given firm so that it is a major and perilous event to enter a new area of technology comparable to birth of a start-up firm with its own science and technology base. Mansfield (1995) focuses on the ties between particular industries and academic disciplines. Darby and Zucker (1999) attempt to capture these insights in a set of seven area clusters which can be used to compare activity in journal articles (Institute for Scientific Information 1981-1997), university doctoral programs (National Research Council 1995), and patents (Zucker and Darby 1999a).

These clusters are used here with two exceptions: First, the humanities and social sciences are dropped for this study because they have little specific applicability to particular high technology industries. Second, we have been developing a public digital library NanoBank.org for the emergent, highly interdisciplinary nanotechnologies which utilize the unique properties that occur at the atomic and sub-atomic level (Zucker and Darby 2006b). We subtract those articles and patents identified for NanoBank.org from the area in which they would have been previously classified. Those nanotechnology patents are identified as the union of a standard Boolean search of titles, abstracts, and patent descriptions using nano-specific

terms and an iterative probabilistic method which scores words and phrases according to their relative frequency of appearance in a learning set of expert-identified nano-articles and articles and patents generally (Ma, Furner, Zucker, and Darby 2006; Zucker, Darby, Ma, Furner, and Liu 2006). Appendix Table A.1 details the Web of Science subject category codes, International Patent Classes, and National Research Council doctoral program names corresponding to each of these five science and technology areas other than nanotechnology.

II.A.2. Star Scientists and Engineers

Zucker and Darby 1996 and Zucker, Darby, and Brewer (1998) introduced the concept of biotechnology stars based upon productivity measured by the number of articles written through 1990 which reported a genetic-sequence discovery. That concept has been generalized to other cases of obvious linkage between development in science and in high technology, such as nanotechnology (Darby and Zucker 2006) and stem cells (Zucker and Darby 2006a). We here apply the star scientist concept to all fields of science and engineering and test the hypothesis that locally active star scientists generally exert an independent positive effect on commercial development (here, firm entry and patenting) in related high-technology industries.

Star scientists previously have been empirically identified by field specific definitions which pick out a highly productive group comprising on the order of 0.5-1.0 percent of all scientists authoring any papers in the field of interest. The *ISIHighlyCited.com* website offers a database of the top 250 individual researchers in terms of 20-year-rolling-window citation counts in each of 21 subject fields – 19 of which are science and engineering fields. Information for each highly cited author includes curricula vitae, (potentially) full listings of publications, and links where available to the full bibliographic information indexed in the *ISI Web of Science®*.

Since data quality depends on the cooperation of the highly cited authors, data quality varies with many missing values. Nonetheless, the database seems to offer a comprehensive list of top researchers across the breadth of science and engineering and the research reported here largely validates its usefulness as an empirical tool for identifying star scientists.

Altogether we thus identify 5,401 star scientists, one or more of whom are credited with authorship of some 520,839 articles that appear in the *ISI Web of Science*® database. If we count articles each time a star scientist appears, there are 571,068 article authorships. For a sizeable minority (2,042 or 37.8%) of these stars, exactly 10 ISI articles are listed as their full publication list – apparently representing those listed on an NSF or NIH abbreviated vita or supplied by ISI itself.[3] On completion of our person-matching project for all ISI article authors and U.S. patent inventors since 1981, we will be able to add to that article count, but we have not done so at this point. The articles are used to identify where the stars are active based on those 299,583 cases 52.5% of the star authorships) where their affiliation is unambiguous because they are the corresponding author, the sole author, or there is only 1 listed corresponding or research address for a journal that reports multiple addresses on other articles in the same year.[4]

We have used these addresses to identify each U.S. region or non-U.S. country in which these star scientists were active 1981-2004. We code the stars as active in a region from two years before their first publication there (based on research and publication lags in a 40-star CV study) until they move to another location. During transitional phases they are coded as active for up to two years in both locations. Stars who maintain long-term affiliations in multiple countries also are coded as active in each location.

The author is assigned to each of one or more science and technology areas in those years when that area is reflected in the article keywords (author keywords and ISI Keywords Plus)

appearing in all of their publications (whether we have an assured location or not). This potential double-counting of both areas and locations is not a major concern in practice: the average number of stars per year across all countries, areas, and years is only 5,038 or 33.3% more than the 3,780 average number of unique individuals per year. Nonetheless, we believe that it more accurately captures the ability of these extraordinary individuals to catalyze the founding of a firm or entry of an existing firm into a new technology area.

II.A.3. Firm Entry into a New Area of Technology

Darby and Zucker (2006) have shown that the first time in which a firm publishes an article in an area is a good indicator of entry into high-technology industries. We generalize that approach here by counting as entry the first-to-appear of publications with a firm-affiliated author or patents assigned to the firm at the time the patent is granted (assignee at issue). Appearance is dated by article publication or patent application date. For the country data set, a particular firm can enter each time it first publishes or patents in a given technology area in a given country. Firm location corresponds to the address given on the article or the region or non-U.S. country of each inventor on a patent (for over 89% of patents there is only one region or non-U.S. country). For the U.S. data set, a particular firm can enter each time it first publishes or patents in a given technology area in a given region. Thus, entries by a firm in a given area and U.S. region are not counted in the country data set after the first time the firm enters that technology area in any region in the U.S. In practice, the vast majority of firms publish and/or patent in only a single area and single country or region as defined by the addresses of authors or inventors.

It is important to emphasize that having used articles with firm-affiliated authors and patents with firm assignees to define our primary dependent variable, such articles and patents cannot be used in the construction of any of the independent variables for the empirical analysis.

Even if they are also a principal in a firm, star scientists generally give their affiliation as a university or research institute. However, we have found star collaborations with firm employees to be particularly powerful indicators of future firm success. There were 38,100 articles authored by stars either with or as firm employees – 7.3% of all stars' articles. However, only 3,291 stars – 59.6% of all stars – ever had any articles as or with firm employees.

When it comes to establishing property rights to their inventions, however, 28,827 or 63.3% of stars' patents have a firm listed as or among the assignees at issue out of their 45,542 total U.S. patents.[5] In contrast, only 5,040 or 11.1% have a university listed as or among the assignees at issue. The number of stars listed as inventors on one or more patents was 2,771 of which 1,976 (71.3% of those with any patents) had one or more patents with a firm listed as or among the assignees at issue. However, 1,354 of the stars with firm-assigned patents also had articles linked to firms, so patents identify only 622 additional stars with some firm involvement.

A total of 3,913 stars (72% of all stars) have been identified to have some relationship to a firm at some point in their career, which may range from arms length patent transfer or collaboration with an employee through consulting, advisory or principal role to employment and/or ownership. Of this total, 84.1% can be identified by co-publication, 50.5% by patent assignment, with a 34.6% overlap identified by both (84.1% + 50.5% – 34.6% = 100.0%).

II.A.4. Non-University Patenting

The second dependent variable non-university patenting measures an aspect of the development of commercial technology by region or country. We use non-university patenting

(i.e., patents with no university as any of the assignees at issue) rather than firm patents because the bulk of those patents not assigned to identified firms or universities appear to be commercial in nature although we have not identified the assignee as a particular firm. These patents are geolocated by the inventors' addresses as a more reliable indicator of where the research was done than the assignee address which is often the firm's headquarters. Where there are $n > 1$ inventors, the patent is counted as $1/n$ for the location of each inventor's address.

II.A.5. Knowledge Stocks

We used three separate sources to develop measures of the non-firm science base by region (or country) and year: university articles, university patents, and high impact articles. In constructing these measures we first delete all articles for which a firm is included on any of the reprint and research addresses (articles) or as an assignee at issue since those articles or patents could have been used to define entry and introduce a subtle bias into the analysis. High impact articles are those in the *High Impact Papers* database of the ISI cited above. University articles and patents are those with a university (but no firm) named either on any of the reprint and research addresses or as an assignee at issue. High-impact articles exclude only those with firm authors, but are nearly all also included in the university articles file.

With firm observations excluded, all the articles and patents used in these variables can belong to either universities or "other" organizations (such as national labs or research institutes). In case of multiple organizational affiliations for an observation (due to the presence of multiple research addresses for articles or multiple assignees for patents), each organization is credited with the corresponding fractional amount for that observation. For example, if a patent (article) has listed 1 university and 1 national lab as assignees (research addresses), each is credited ½, so only 0.5 is added to the university patent (article) total for the corresponding total.

Knowledge stocks are measured as conventional (see Griliches 1990) in the economics of science and technology literature as a perpetual inventory with depreciation rate $\delta = 0.20$:

(1) $\quad K_{i,t} = I_{i,t} + (1 - \delta)K_{i,t-1}$

where $K_{i,t}$ is the knowledge stock of type i (denoting science and technology area and region or country) at time t and $I_{i,t}$ is the input series for this knowledge stock – alternatively counts by region/country and science and technology area of (non-firm) university articles, university patents, and high impact articles.

While creating the input series counts for each of these measures, we determine the articles or patents in each science and technology area. (If an article or patent that can be considered belonging to more than one area, each area is credited a fraction.[6]) These science and technology area counts are then allocated to U.S. regions and/or to countries with each research address or assignee address receiving equal credit.[7] For example, if an article had seven authors and listed two British addresses and one French address, Britain would get two thirds of the article's credit and France one-third since we cannot assign each of the seven authors to any particular research address. After creating the basic counts for each year by area and region or country, we use formula (1) to accumulate them year by year with a 20% depreciation rate to create the knowledge stocks by science and technology area, region or country, and year for each of the two analysis data sets (U.S. regions and top-25 science and technology countries).

II.A.6. Other Variables

The employment and average wage-per-job data for the U.S. regional data set were downloaded from the BEA website (http://www.bea.gov/bea/regional/reis/) and the wages were deflated to thousands of 2000 dollars per year using the BEA's chain-type price index for consumer expenditures. The employment data for the 25-country data set were obtained from

IMF (http://ifs.apdi.net/imf/) with the exception of Taiwan data which were downloaded from http://2k3dmz2.moea.gov.tw/gnweb/english/e_main.aspx?Page=D. Missing observations were interpolated by linear regressions.

II.B. Estimation Method

There is some controversy among practitioners as to the best method to estimate count models with a poisson-like structure. The mean and variance of the poisson distribution both equal the single parameter λ. However, overdispersion (variance > mean) will be observed if there is unobserved heterogeneity across observations. This is frequently dealt with by assuming that the parameter λ is distributed according to

(2) $\log \lambda = x\beta + \varepsilon$

where the disturbance term ε is distributed as a gamma distribution. Kennedy (1998, pp. 247-248) notes that this "leads to a negative binomial distribution for the number of occurrences, with mean λ and variance $\lambda + \alpha^{-1}\lambda^2$ where α is the common parameter of the gamma distribution." Estimation by negative binomial – or worse, we believe, negative binomial if poisson fails a pretest for overdispersion – is a frequent recourse for dealing with potential overdispersion.

We have continually avoided this practice in our own work because if the binomial is inappropriate (i.e., ε is not gamma-distributed) the estimated coefficients will be biased with the negative binomial method while these coefficients are estimated without bias using the poisson method even if the negative binomial method is appropriate. We are persuaded by Wooldridge (1991) that the better way to deal with possible overdispersion (and underdispersion which also occurs) is to estimate standard errors for the coefficients which are unbiased across a range of plausible models. In the past we have used Wooldridge's regression based method which works but

requires writing your own subroutine. We are now using the Stata 9.0 statistical package which includes robust standard errors as an option for poisson estimation which solves the problems discussed by Wooldridge and others.

III. Empirical Results

This section discusses our empirical results for both firm entry (III.A) and non-university patenting (III.B). We use the Stata 9.0 statistical package for poisson estimation with robust standard errors for all the estimates presented in these subsections for the reasons just discussed. The third subsection examines whether the major determinants in these regressions are becoming more diffuse or more concentrated over time.

III.A. Entry into New Technology Areas

Our empirical results for entry of firms into new (to them) science and technology areas are reported in Table 2 for the U.S. regions data set, Table 3 for the top-25 science and technology countries data set, and Table 4 for the top-24 non-U.S. science and technology countries data set.

First, however, it is important to emphasize the major result: the number of star scientists and engineers active in a region or country has positive (with one exception) and generally significant effects on the probability of a firm entering in all six science and technology areas. These effects are numerically substantial as illustrated in Figure 1. These results are even stronger – as reported in Appendix A – if the analysis is restricted to the first third of the stars who met a higher ISI hurdle than required of later selectees.

The first 6 quartets of bars in Figure 1 illustrate the effects of stars in U.S. regions (Table 2), the next 6 represent these effects for the 25 country regressions (Table 3), and the last six for the 24 countries with the U.S. excluded (Table 4). The second bar in each quartet represents the base for comparison (value 1.00) which is the probability per unit of time of firm entry if all variables in the poisson regressions are set equal to their mean value. The first bar represents the probability of firm entry if there were instead exactly one active star in the science and technology area in an otherwise representative region or country divided by the probability if all variables were at their mean. Therefore, the first bar is lower than the second in cases where the mean number of active stars is greater than one and higher if that mean is less than one. The third and fourth bars in a quartet represent the relative probability of firm entry when the active stars are set 1 or 2 standard deviations above their mean.

For example, the first quartet plotted is for the Biology, Chemistry & Medicine based on the U.S. regional regressions. It shows that a region with 2 standard deviations more stars than average in this area will have a probability of a firm entering the area on any given day as 1.7 times that for an otherwise like region with only the mean number of active stars. For all 25 countries, the corresponding ratio is 16.0 times the base probability. Thinking that this might reflect something special about the U.S., we excluded it in the 24-country regressions but still have a 2.9-fold probability for a country with 2 standard deviations above average active stars compared to a country with the mean number of stars.

Figures 2-5 compare cumulative active star years (stars) and firm entry (circles) in U.S. and world for biology/chemistry/medicine and nanotechnology. The size of the stars and circles indicate the numbers of each, but note the change in scale in moving from Figure 2 to 3 or 4 to 5.

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Focusing now on Table 2, we see that the stars do not merely have an additional effect on firm entry over and above that of the discoveries by them and others included in the high impact articles, university articles, and university patents knowledge stocks, but that these variables are not even consistently positive in their impact with stars included.[8] This seems to say that top scientists and engineers are the ferment driving the formation and transformation of high-tech firms, not their inventions separate from themselves. The economic geography variables seem to be well behaved, with both the size of the region and the average education level (captured here by average wage) having significant positive effects on the entry of firms into new areas. The dummy variables were included to capture the fact that some of the entries which will be eventually observed using our methodology cannot be seen yet since many applied for patents from 2002-2004 were still pending when our data set was created and even some articles to appear in journals with 2004 cover dates had yet to be published. These dummies had the expected negative sign and increasing size indicating increasing truncation effects.

The results for the 25-country regressions in Table 3 are similar to Table 2 with the notable exception that the university articles stock does appear to have a consistent positive and mostly significant effect on firm entry. Economic geography loses its consistent effects, perhaps because of our inability to find a commensurable average wage or education level variable and perhaps also because of the very large size of China and India. The 2002-2004 dummy variables follow the same general pattern except for computing/IT and semiconductors where there are two borderline significant positive values.

We were concerned that something special about American institutions or culture or simply a greater propensity to obtain a U.S. patent might distort the results in Table 3, so we reran all the poisson regressions with the U.S. excluded from the data set. The results in Table 4

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are similar to those in Tables 2 and 3, suggesting that the U.S. was not an unduly influential observation.

Appendix A reports matched regressions where the empirical definition of stars is restricted to the first third (1,838 or 34%) of the ISI Highly Cited, who on average met a somewhat higher hurdle than subsequent highly cited authors. Star scientists have a significant, positive effect in every industry when the models of Tables 2 and 3 are rerun with these data, suggesting that stars might be better defined by starting with the ISI Highly Cited data and then imposing further screens. We will explore that hypothesis in future research.

Taken as a whole, the results show that the physical presence of star scientists and engineers plays an important role in the formation and transformation of high-tech firms. There is some evidence, especially in the country regressions, that academic discoveries (or unmeasured discoverers) play an independent role as well. The economic geography variables work well in the U.S. regional context, but do not translate well in the international context.

III.B. Non-university Patenting

Our attempt to explain non-university patenting using stars, academic knowledge stocks, and economic geography were not so successful as reported in Tables 5, 6, and 7. The university articles knowledge stock does show consistent positive effects. Education levels as measured by average wages are also consistently positive for the U.S. regional results. Our problem may be that the three knowledge stocks are correlated not only among themselves but with the star counts (see Appendix B). Apparently, any positive effect of the local academic knowledge stock or stars is much weaker than is the case for firm entry into new science and technology areas.

While the results for patenting are not commensurate with the effort that went into the analysis, they do illustrate one important point: There is nothing inherent in the empirical methodology that artificially creates significant coefficients.

III.C. Concentration or Diffusion of Stars and Knowledge

Given the clear importance of stars for firm entry and – in the country regressions – also the university articles knowledge stock, it is interesting to know how these change over time. Table 8 reports the correlation coefficients between the growth rates and levels of stars and each of the three knowledge stock variables by science and technology area. If this correlation is significantly positive, it means that those regions with above average levels of the variable are also growing faster in percentage terms implying increasing concentration over time: the rich get richer. On the other hand, a significant negative value of this correlation coefficient means below average regions or countries are growing more rapidly and above average ones less rapidly implying diffusion or a tendency toward equalization over time.

Stars show a clear tendency toward concentration by area in both the U.S. regional data set and for the 24 non-U.S. countries, with the effect weakest for the Biology, Chemistry, and Medicine area. This pattern is much weaker in the 25 country data set where all correlations are positive but only 1 (nanotechnology) more than marginally significant. We interpret these results as reflecting two contradictory motivations for movement of stars. First stars tend to move to where there are more other stars – for example from lower to higher ranked universities – as well as to where there are greater commercial opportunities (Zucker and Darby (1999b).[9] Overlaying this pattern during the last quarter century, however, are movements of many U.S. trained foreign students who build successful careers in American academe, perhaps moving

from lower to higher ranked U.S. universities but choose to return home when their native countries develop sufficient strength in their disciplines to both seek them out and to be attractive (Saxenian 2005). This weakens the tendency toward concentration when the U.S. is in the country data set, but not when it is out. Since this effect is present to a somewhat similar degree in all American universities, the reverse brain drain of expatriate stars affects the average growth rate of stars in the U.S. without weakening the positive correlation across countries.

For the knowledge stocks in the U.S regions and 25 countries data sets, there is a general tendency toward diffusion or equalization of knowledge stocks, with significant negative correlations appearing most consistently for university articles – possibly the diffusion of the "publish or perish" standard from elite American universities to others both domestically and internationally. Domestic diffusion may have kept up the overall growth rate of American knowledge stocks, since the pattern of diffusion of university articles and even high impact articles is much stronger among the 24 non-U.S. countries.

IV. Conclusions

We have shown that it is possible to generalize the definition of star scientists and engineers far beyond its biotechnology origins. We have also seen that doing so offers convincing evidence that these extraordinary people play a key role in the formation and transformation of high-tech firms. We have seen that while there is a general tendency toward diffusion of academic knowledge stocks, the movement of star scientists and engineers is toward concentration. One offsetting trend is the tendency for foreign-born American academics to return home when their country becomes strong in their disciplines.

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Appendix A

The Web of Science subject category codes, International Patent Classes, and National Research Council doctoral program names corresponding to each of these six science and technology areas are listed in Table A.1.

In the first version of this paper (Zucker and Darby 2006c) produced to meet a conference deadline, we reported results for the first 1,838 star scientists which we had downloaded from isihighlycited.com, parsed, cleaned, and matched. Since our downloading procedure was based on ISI's serial ID numbers, we downloaded all 888 of the individuals collected by ISI in the years 2000 through 2001 and the first 950 collected in the year 2000. ISI appears to have selected only the very most highly cited authors for inclusion in the first year of ISI HighlyCited, with those appearing in later years clearing progressively lower hurdles. The combination of our systematic download procedure and first-draft deadline inadvertently produced an enriched sample of more stellar stars than the full set of 5,401 on which we focus for this paper. Tables A.2-A.7 report the regression results obtained for this smaller set of stars and correspond exactly in format and order to the text Tables 2-7. Table A.8 reports sample statistics for this subset corresponding to text Table 1.[10]

We will not trespass on the patience of reader or editor by going through a detailed discussion of the results. We believe that they may be fairly summarized as at least as strong and sometimes stronger evidence than the full-sample results for the direct importance of top scientists and engineers for firm creation and patenting. Since these stars are princes and princesses of serendipity, we are doubly grateful for our fortunate confirmation of the theory.

Appendix B

Table B.1 provides the interested reader correlation coefficients for variables used in the empirical analysis reported in the main text.

An alert referee asked whether our results on firm entry might not be an artifact of our method of detecting firms newly entering an area by publication or patenting therein. Could the large productivity of the star scientists account for many of the articles and patents which we use to detect entry? Tables B.2 through B.4 correspond to text Tables 2-4 with the exception that we exclude any entry for a firm for which we detected its entry due to an article or patent which included a star scientist as either author or inventor. This is an acid test since we are excluding firms for which we might detect entry from a subsequent non-star article or patent. Since the results in Tables B.2-B.4 correspond closely to those in Tables 2-4, we conclude that the reported effect on entry is real and not an artifact of our measurement methods.

References

Darby, Michael R., and Lynne G. Zucker, *California's Science Base: Size, Quality and Productivity*, Sacramento, CA: California Council on Science and Technology, 1999.

Darby, Michael R., and Lynne G. Zucker, "Change or Die: The Adoption of Biotechnology in the Japanese and U.S. Pharmaceutical Industries," *Comparative Studies of Technological Evolution*, 2001, 7: 85-125.

Darby, Michael R., and Lynne G. Zucker, "Grilichesian Breakthroughs: Inventions of Methods of Inventing in Nanotechnology and Biotechnology," *Annales d'Economie et Statistique*, 2006 in press.

Griliches, Zvi, "Patent Statistics as Economic Indicators: A Survey," *Journal of Economic Literature*, December 1990, 28(4):1661-1707.

Institute for Scientific Information, *Science Citation Index*, machine-readable data bases, Philadelphia: Institute for Scientific Information, 1981-1997.

Institute for Scientific Information, *Science Citation Index Expanded, Social Sciences Citation Index, Arts & Humanities Citation Index, and High Impact Papers,* machine-readable data bases, Philadelphia: Institute for Scientific Information, 2005.

Johnson, Kenneth P. and John R. Kort "2004 Redefinition of the BEA Economic Areas," *Survey of Current Business*, November 2004, pp. 68-75.

Kennedy, Peter, *A Guide to Econometrics*, fourth edition, Cambridge, MA: The MIT Press, 1998.

Ma, Hongyan, Jonathan Furner, Lynne G. Zucker, and Michael R. Darby, "Automatic Selection of Patents and Scientific Articles for NanoBank: An Integrated Probabilistic (IP)

Approach," paper for presentation at the ACM & IEEE Computing Joint Conference on Digital Libraries, 2006.

National Research Council., *Research-Doctorate Programs in the United States: Data Set*, machine-readable data base, Washington, DC: National Academy Press, 1995.

Saxenian, AnnaLee, "From Brain Drain to Brain Circulation: Transnational Communities and Regional Upgrading in India and China," *Studies in Comparative International Development*, 2005, 40(2): 35-61.

Tushman, Michael L., and Philip Anderson, "Technological Discontinuities and Organizational Environments," *Administrative Science Quarterly*, March 1986, 31(1): 439-465.

Wooldridge, Jeffrey M., "On the Application of Robust, Regression-Based Diagnostics to Models of Conditional Means and Conditional Variances," *Journal of Econometrics*, January 1991, 47: 5-46.

Zucker, Lynne G., and Michael R. Darby, "Star Scientists and Institutional Transformation: Patterns of Invention and Innovation in the Formation of the Biotechnology Industry," *Proceedings of the National Academy of Sciences*, November 12, 1996, 93(23): 12709-12716.

Zucker, Lynne G., and Michael R. Darby, *California's Inventive Activity: Patent Indicators of Quantity, Quality, and Organizational Origins*, California Council on Science and Technology, 1999. (1999a)

Zucker, Lynne G., and Michael R. Darby, "Star Scientist Linkages to Firms in APEC and European Countries: Indicators of Regional Institutional Differences Affecting Competitive Advantage," *International Journal of Biotechnology*, 1999, 1(1): 119-131. (1999b)

Zucker, Lynne G., and Michael R. Darby, "Capturing Technological Opportunity Via Japan's Star Scientists: Evidence from Japanese Firms' Biotech Patents and Products," *Journal of Technology Transfer*, January 2001, 26(1/2): 37-58.

Zucker, Lynne G., and Michael R. Darby, "Real Effects of Policy Change in Industry Development in Stem Cells," paper presented at the Stem Cells: Promise and Peril in Regenerative Medicine Conference, UCLA Center for Society and Genetics, Los Angeles, CA, February 3-4, 2006. (2006a)

Zucker, Lynne G., and Michael R. Darby, "Socio-economic Impact of Nanoscale Science: Initial Results and NanoBank," in Mihail C. Roco and William S. Bainbridge, eds., *Societal Implications of Nanotechnology*, Springer Science and Business Media, 2006 in press. (2006b)

Zucker, Lynne G., and Michael R. Darby, "Movement of Star Scientists and Engineers and High-Tech Firm Entry," National Bureau of Economics Research Working Paper No. 12172, April 2006. (2006c)

Zucker, Lynne G., Michael R. Darby, and Jeff Armstrong, "Geographically Localized Knowledge: Spillovers or Markets?" *Economic Inquiry*, January 1998, 36(1): 65-86.

Zucker, Lynne G., Michael R. Darby, and Jeff Armstrong, "Commercializing Knowledge: University Science, Knowledge Capture, and Firm Performance in Biotechnology," *Management Science*, January 2002, 48(1): 138-153.

Zucker, Lynne G., Michael R. Darby, and Marilynn B. Brewer, "Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises," *American Economic Review*, March 1998, 88(1): 290-306.

Zucker, Lynne, Michael R. Darby, Hongyan Ma, Jonathan Furner, and Robert Liu, "Knowledge and Organizational Prologues of the Evolution of Nanotechnology," National Bureau of Economics Research Working Paper No. [in process], March 2006.

Zucker, Lynne G., Michael R. Darby, and Máximo Torero, "Labor Mobility from Academe to Commerce," *Journal of Labor Economics*, July 2002, 20(3): 629-660.

[1] The 25 countries are: Australia, Austria, Belgium, Brazil, Canada, China, Denmark, Finland, France, Israel, India, Italy, Japan, Germany, the Netherlands, Norway, Poland, South Korea, Spain, Sweden, Switzerland, Taiwan, the United Kingdom, the United States, and the USSR & Russia counted as the same country.

[2] If $\lambda = X\beta + \varepsilon$ (i.e., has a disturbance term ε) and if so the distribution of ε affects the estimation methodology used as discussed in Section II.B below.

[3] Another 3.2% of the stars are listed as having 5-9 ISI-indexed articles, presumably having cited works in press or conference volumes on the NSF/NIH vita. We dropped entirely from the analysis those 30 highly cited authors out of 5,431 for which there are no ISI-indexed articles listed.

[4] ISI article data do not distinguish which address (normally an organization) goes with which author except for a possible single author designated corresponding author who then matches (at least) to the corresponding address). The cases indicated in the text are those for which the star scientist can be definitively located with an address. The 299,583 authorships corresponded to 276,182 different articles, with the difference (23,401) all accounted for by multiple star authors with a single address.

[5] Since we cannot rely on a definitive list of articles from ISI, we performed a name match based on exact match of both the last name and the first name and to the extent they are available middle name or initial. This method probably results in an overestimate of the number of star patents with false positives outweighing missed matches due to misspellings.

[6] Each International Patent Classification code and each ISI Web of Science category code has been associated with one major science and technology area. Since patents can report more than

one IPC code (and journals more than one ISI category), we can have observations associated with more than one major science and technology area. If a patent (or article) has n IPC codes (or n ISI categories), each science and technology area is credited with 1/n for that patent (article) for each IPC code (ISI category) on it which falls in the area.

[7] If an article has research address listed they include the reprint address and so that is not counted again. If there is only a reprint address, full credit for the article goes to that location. Since this assignment is made by address, the sum of the U.S. regional assignments in principle equals the number assigned to it in the 25-country data set. The only differences arise because of a few U.S. observations which were omitted in the U.S.-only data set because we were unable to assign the partial or garbled address to a region.

[8] In results not reported here, we checked that these variables do have their usual positive impact if stars are excluded from the regressions. If, on the other hand, these variables are excluded then the estimated impact of the stars generally increases. This is to be expected given the moderately high correlations among these explanatory variables reported in Appendix B, Table B.1.

[9] A seemingly related paper, Zucker, Darby, and Torero (2002), focused not on inter-regional or international mobility of biotech stars, but mobility from purely academic to either affiliated or linked (co-authoring) with firm scientists.

[10] These Tables differ slightly from the tables originally reported in Zucker and Darby (2006c) due to continued cleaning of the data and correction of typographical errors.

Table 1. Summary Statistics for Variables Used in Empirical Analysis, 1981-2004

Variables	U.S. Regions					Top-25 Sci. & Tech Countries					Top-24 non-U.S S&T Countries				
	N	Mean	S.D.	Min	Max	N	Mean	S.D.	Min	Max	N	Mean	S.D.	Min	Max
Entry of Firms into:															
Biology/Chemistry/Medicine	4296	7.2	15.9	0	165	600	45.8	149.4	0	1067	576	21.8	24.9	0	125
Computing/Information Technology	4296	3.2	9.8	0	203	600	20.7	80.5	0	738	576	7.3	10.3	0	56
Nanotechnology	4296	1.9	6.2	0	87	600	12.5	53.5	0	483	576	5.4	9.7	0	71
Semiconductors	4296	2.7	7.3	0	90	600	24.5	80.7	0	657	576	9.3	12.2	0	73
Other Sciences	4296	3.6	8.3	0	104	600	24.5	89.0	0	609	576	9.5	13.5	0	66
Other Engineering	4296	12.8	24.7	0	248	600	72.8	287.0	0	2107	576	29.6	42.3	0	207
Non-university patenting:															
Biology/Chemistry/Medicine	4296	30.6	147.7	0	1986.4	600	729.8	2081.8	0	14783.0	576	344.7	663.8	0	4079.3
Computing/Information Technology	4296	20.4	165.2	0	4130.3	600	446.5	1709.5	0	14101.2	576	214.9	828.1	0	9188.5
Nanotechnology	4296	9.8	73.7	0	2089.8	600	247.8	966.5	0	8245.5	576	141.2	625.5	0	7967.5
Semiconductors	4296	5.4	46.7	0	1126.7	600	162.1	544.0	0	4453.6	576	96.1	347.4	0	3039.5
Other Sciences	4296	11.1	50.4	0	946.4	600	311.7	881.2	0	6453.9	576	164.3	446.2	0	4102.3
Other Engineering	4296	71.9	262.1	0	3422.7	600	2286.5	6261.7	0	41986.1	576	1241.1	3133.4	0	23161.3
Star Scientists & Engineers Active															
Biology/Chemistry/Medicine	4296	11.3	33.8	0	256	600	126.2	395.8	0	2385	576	46.8	59.3	0	300
Computing/Information Technology	4296	2.5	9.2	0	96	600	25.4	87.3	0	516	576	7.9	9.4	0	41
Nanotechnology	4296	0.3	1.6	0	22	600	3.9	14.6	0	116	576	1.7	3.4	0	20
Semiconductors	4296	2.0	7.0	0	79	600	20.7	70.5	0	472	576	6.6	7.8	0	41
Other Sciences	4296	1.6	6.3	0	62	600	17.0	57.7	0	361	576	5.6	8.5	0	42
Other Engineering	4296	0.8	3.2	0	35	600	8.6	29.3	0	200	576	2.7	4.3	0	25
High Impact Articles Knowledge Stock															
Biology/Chemistry/Medicine	4296	13.1	55.0	0	518.9	600	277.3	834.2	0	4,911.6	576	115.0	156.2	0	870.3
Computing/Information Technology	4296	2.5	11.5	0	123.5	600	58.4	162.4	0	1,194.3	576	27.0	34.6	0	248.2
Nanotechnology	4296	0.5	2.9	0	65.9	600	15.1	53.7	0	513.1	576	7.6	14.4	0	96.9
Semiconductors	4296	2.0	9.7	0	115.4	600	53.4	146.1	0	907.9	576	25.3	32.0	0	137.1
Other Sciences	4296	5.0	25.1	0	246.0	600	96.7	324.2	0	1,994.1	576	34.7	52.6	0	269.4
Other Engineering	4296	1.3	7.3	0	75.2	600	30.4	91.2	0	528.3	576	12.6	18.7	0	103.4
University Articles Knowledge Stock															
Biology/Chemistry/Medicine	4296	1485.0	5068.2	0	61,361.2	600	46272.6	108860.9	64.0	729,673.6	576	26210.2	31255.5	64.0	159,973.2
Computing/Information Technology	4296	90.9	317.1	0	3,803.9	600	3501.5	7268.2	6.0	49,950.6	576	2207.5	2476.7	6.0	12,449.2
Nanotechnology	4296	20.0	94.2	0	1,509.7	600	953.9	2557.6	0	24,685.3	576	654.0	1338.9	0	9,289.5
Semiconductors	4296	159.7	577.8	0	6,030.3	600	7438.5	13386.2	24.4	81,232.2	576	5198.3	6455.8	24.4	36,102.0
Other Sciences	4296	99.7	374.2	0	4,161.1	600	3245.2	7703.8	3	48,111.6	576	1816.8	2207.4	3	11,874.8
Other Engineering	4296	44.0	158.6	0	1,691.6	600	1534.7	3622.9	1	23,672.5	576	875.5	1166.2	1	7,241.4
University Patents Knowledge Stock															
Biology/Chemistry/Medicine	4296	8.7	40.4	0	564.3	600	134.7	672.2	0	5259.8	576	17.4	37.4	0	262.0
Computing/Information Technology	4296	0.7	3.9	0	66.6	600	11.3	61.0	0	576.3	576	1.3	3.6	0	35.5
Nanotechnology	4296	3.3	21.7	0	415.8	600	53.5	334.6	0	3599.1	576	6.3	18.0	0	237.4
Semiconductors	4296	0.3	2.4	0	44.5	600	5.8	28.5	0	294.8	576	0.8	4.4	0	92.8
Other Sciences	4296	2.2	12.3	0	224.4	600	34.8	163.4	0	1281.0	576	4.7	10.4	0	58.9
Other Engineering	4296	3.4	15.3	0	255.8	600	62.1	291.6	0	2330.0	576	9.5	20.0	0	129.1
Total Employment in Region/Country	4296	0.8	1.4	0.0	12.9	600	47.3	123.3	1.0382	752	576	44.2	124.9	1.0	752.0
Average Wage per Job in Region	4296	26.2	4.1	18.3	51.0	—	—	—	—	—	—	—	—	—	—

Notes: 1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated
Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Tech-
nology articles & patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.
2. U.S. regions are the 179 functional economic areas defined by the U.S. Bureau of Economic Analysis (Johnson and Kort 2004).

Table 2. Firm Entry into New Technologies – Poisson Regressions
U.S. Functional Economic Regions, 1981-2004

Explanatory Variables	Science and Technology Areas of Firm Entry					
	Bio/Chem/Med	Computing/IT	Nanotechnology	Semiconductors	Other Sciences	Other Engineering
Star Scientists & Engineers Active in Region/ Country in Same S&T Area as Entry	0.0077*** (0.0008)	0.0088 (0.0058)	0.0459*** (0.0139)	0.0045 (0.0059)	0.0173*** (0.0031)	0.0355*** (0.0062)
High Impact Articles Knowledge Stock in Same S&T Area as Entry	-0.0012* (0.0006)	0.0292*** (0.0033)	0.0456* (0.0224)	0.0402*** (0.0055)	0.0037*** (0.0011)	-0.0295*** (0.0070)
University Articles Knowledge Stock in Same S&T Area as Entry	0.0000* (0.0000)	-0.0014*** (0.0002)	-0.0012 (0.0008)	-0.0010*** (0.0001)	-0.0006*** (0.0001)	0.0016*** (0.0004)
University Patents Knowledge Stock in Same S&T Area as Entry	-0.0048*** (0.0009)	-0.0075 (0.0078)	-0.0056 (0.0050)	0.0376*** (0.0094)	0.0048** (0.0021)	-0.0090** (0.0032)
Total Employment in Region/Country (millions of persons)	0.0961*** (0.0186)	0.1564*** (0.0261)	0.0971*** (0.0028)	0.2391*** (0.0341)	0.1921*** (0.0191)	0.1434*** (0.0171)
Average Wage per Job in Region (thousands of 2000 dollars)	0.1287*** (0.0072)	0.1783*** (0.0094)	0.1990*** (0.0098)	0.1318*** (0.0088)	0.1161*** (0.0083)	0.1213*** (0.0065)
Constant	-1.8895*** (0.1872)	-4.1122*** (0.2459)	-5.1264*** (0.2627)	-3.0198*** (0.2278)	-2.2201*** (0.2225)	-0.9775*** (0.1713)
Dummy = 1 in 2002, else 0	-0.8422*** (0.1117)	-0.9257*** (0.1033)	-0.7564*** (0.1291)	-0.7297 (0.1170)	-0.9511*** (0.1399)	-1.1007*** (0.1127)
Dummy = 1 in 2003, else 0	-1.2904*** (0.11512)	-1.6108*** (0.1258)	-1.4691*** (0.1323)	-0.9290*** (0.1189)	-1.2570*** (0.1202)	-1.7382*** (0.1202)
Dummy = 1 in 2004, else 0	-2.0501*** (0.1377)	-2.3881*** (0.1341)	-2.6671*** (0.1747)	-1.5562*** (0.1381)	-2.2833*** (0.1407)	-3.1179*** (0.1432)
Pseudo R²	0.6181	0.5802	0.5278	0.5266	0.5275	0.5822

Notes: Robust standard errors in parentheses below coefficient estimates. N = 4296. Significance levels: ^ 0.10, * 0.05, ** 0.01, ***0.001
1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Technology articles & patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.
2. Knowledge stocks are computed as a perpetual inventory of the indicated series with 20% depreciation applied to the prior year's stock.

Table 3. Firm Entry into New Technologies – Poisson Regressions
Top-25 Science & Technology Countries, 1981-2004

Explanatory Variables	Science and Technology Areas of Firm Entry					
	Bio/Chem/Med	Computing/IT	Nanotechnology	Semiconductors	Other Sciences	Other Engineering
Star Scientists & Engineers Active in Region/ Country in Same S&T Area as Entry	0.0035*** (0.0001)	0.0140*** (0.0025)	0.0651*** (0.0049)	0.0133* (0.0055)	0.0192*** (0.0038)	0.0254** (0.0081)
High Impact Articles Knowledge Stock in Same S&T Area as Entry	-0.0019*** (0.0001)	-0.0043** (0.0014)	-0.0008 (0.0045)	-0.0031 (0.0027)	-0.0036*** (0.0007)	0.0024 (0.0023)
University Articles Knowledge Stock in Same S&T Area as Entry	0.0000*** (0.0000)	0.0001^ (0.0000)	0.0002*** (0.0001)	0.0000 (0.0000)	0.0002*** (0.0001)	0.0001 (0.0001)
University Patents Knowledge Stock in Same S&T Area as Entry	-0.0010*** (0.0001)	-0.0023^ (0.0013)	-0.0022*** (0.0005)	-0.0034 (0.0027)	-0.0046*** (0.0006)	-0.0019** (0.0006)
Total Employment in Region/Country (millions of persons)	-0.0017*** (0.0003)	-0.0002 (0.0003)	0.0004 (0.0004)	-0.0001 (0.0004)	-0.0004 (0.0003)	-0.0001 (0.0004)
Constant	2.5454*** (0.0532)	1.7118*** (0.0728)	1.3053*** (0.1304)	2.1689*** (0.1192)	1.7140*** (0.1169)	2.9924*** (0.1118)
Dummy = 1 in 2002, else 0	-0.1958^ (0.1113)	-0.2609 (0.1904)	-0.5906*** (0.1097)	0.2894 (0.1890)	-0.3826* (0.1820)	-0.4882^ (0.2586)
Dummy = 1 in 2003, else 0	-0.3124^ (0.1690)	0.4756^ (0.2585)	-1.2523*** (0.2036)	0.3956^ (0.2110)	-0.9073*** (0.2691)	-0.9040*** (0.2120)
Dummy = 1 in 2004, else 0	-2.1357*** (0.5411)	-0.7148** (0.2402)	-1.6237** (0.5712)	-0.1660 (0.2171)	-2.3861*** (0.5524)	-1.5355*** (0.2039)
Pseudo R²	0.8889	0.8557	0.7737	0.7720	0.8597	0.8589

Notes: Robust standard errors in parentheses below coefficient estimates. N = 600. Significance levels: ^ 0.10, * 0.05, ** 0.01, ***0.001
1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Technology articles & patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.
2. Knowledge stocks are computed as a perpetual inventory of the indicated series with 20% depreciation applied to the prior year's stock.

Table 4. Firm Entry into New Technologies – Poisson Regressions
Top-24 Non-U.S. Science & Technology Countries, 1981-2004

Explanatory Variables	Science and Technology Areas of Firm Entry					
	Bio/Chem/Med	Computing/IT	Nanotechnology	Semiconductors	Other Sciences	Other Engineering
Star Scientists & Engineers Active in Region/ Country in Same S&T Area as Entry	0.0091*** (0.0014)	0.0349*** (0.0076)	0.0434^ (0.0227)	0.0046 (0.0099)	-0.0096 (0.0139)	0.0721*** (0.0186)
High Impact Articles Knowledge Stock in Same S&T Area as Entry	-0.0014* (0.0006)	-0.0106** (0.0039)	0.0305*** (0.0089)	0.0174*** (0.0027)	0.0042 (0.0026)	0.0028 (0.0073)
University Articles Knowledge Stock in Same S&T Area as Entry	0.0000*** (0.0000)	0.0003*** (0.0000)	-0.0000 (0.0001)	0.0000* (0.0000)	0.0002*** (0.0001)	0.0001 (0.0001)
University Patents Knowledge Stock in Same S&T Area as Entry	-0.0001 (0.0009)	-0.0044 (0.0099)	0.0136*** (0.0021)	-0.0068 (0.0076)	-0.0131^ (0.0078)	0.0068** (0.0027)
Total Employment in Region/Country (millions of persons)	-0.0009*** (0.0002)	-0.0010*** (0.0002)	-0.0003 (0.0003)	-0.0004 (0.0003)	-0.0007** (0.0003)	-0.0003 (0.0003)
Constant	2.3401*** (0.0423)	1.0167*** (0.0675)	1.1450*** (0.0604)	1.3694*** (0.0569)	1.5851*** (0.0610)	2.8621*** (0.0565)
Dummy = 1 in 2002, else 0	-0.1984 (0.1570)	-0.5293*** (0.1503)	-0.8945*** (0.2464)	0.1950^ (0.1031)	-0.0923 (0.1486)	-0.7844** (0.2584)
Dummy = 1 in 2003, else 0	-0.2997^ (0.1644)	-0.2219 (0.2099)	-1.5045*** (0.2427)	-0.0479 (0.1450)	-0.5350*** (0.1679)	-1.1910*** (0.2516)
Dummy = 1 in 2004, else 0	-0.8248*** (0.1884)	-1.2219 (0.2628)	-1.7750*** (0.3071)	-0.1240 (0.1136)	-0.9641*** (0.2186)	-2.0436*** (0.2513)
Pseudo R²	0.5905	0.4685	0.4421	0.5009	0.4445	0.4805

Notes: Robust standard errors in parentheses below coefficient estimates. N =576 . Significance levels: ^ 0.10, * 0.05, ** 0.01, ***0.001
1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Technology articles & patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.
2. Knowledge stocks are computed as a perpetual inventory of the indicated series with 20% depreciation applied to the prior year's stock.

Table 5. Non-University Patenting by Science & Technology Areas – Poisson Regressions
U.S. Functional Economic Regions, 1981-2004

Explanatory Variables	Science and Technology Areas of Patents					
	Bio/Chem/Med	Computing/IT	Nanotechnology	Semiconductors	Other Sciences	Other Engineering
Star Scientists & Engineers Active in Region in Same S&T Area as Patent	0.0100*** (0.0017)	-0.0452*** (0.0087)	0.0190 (0.0374)	-0.0116* (0.0059)	-0.0952*** (0.0249)	-0.0534** (0.0172)
High Impact Articles Knowledge Stock in Same S&T Area as Patent	-0.0055*** (0.0015)	0.0507*** (0.0047)	0.0120 (0.0188)	0.0245*** (0.0061)	0.0105*** (0.0019)	-0.0376*** (0.0078)
University Articles Knowledge Stock in Same S&T Area as Patent	0.0002*** (0.0000)	0.0005* (0.0002)	0.0018** (0.0007)	0.0002 (0.0002)	0.0002 (0.0003)	0.0054*** (0.0004)
University Patents Knowledge Stock in Same S&T Area as Patent	-0.0113*** (0.0015)	-0.0186** (0.0071)	-0.0030 (0.0036)	0.0319** (0.0115)	0.0166*** (0.0044)	-0.0193*** (0.0016)
Total Employment in Region (millions of persons)	-0.2855** (0.1000)	-0.0882 (0.0698)	-0.0511 (0.0511)	-0.0158 (0.0801)	0.1741 (0.1124)	0.0333 (0.0223)
Average Wage per Job in Region (thousands of 2000 dollars)	0.1677*** (0.0145)	0.2088*** (0.0219)	0.2085*** (0.0161)	0.1282*** (0.0214)	0.0989*** (0.0243)	0.1397*** (0.0223)
Constant	-1.7754*** (0.3780)	-3.6542*** (0.5808)	-4.1676*** (0.4433)	-2.9353*** (0.5384)	-0.9259 (0.5992)	-0.0538 (0.3627)
Dummy = 1 in 2002, else 0	-0.3401 (0.2421)	0.1380 (0.1842)	0.0371 (0.2109)	0.2757 (0.2181)	-0.2128 (0.2473)	-0.2255 (0.1406)
Dummy = 1 in 2003, else 0	-0.6838* (0.3445)	-0.5419* (0.2345)	-0.2762 (0.2572)	0.2475 (0.2286)	0.0229 (0.1934)	-0.2883* (0.1450)
Dummy = 1 in 2004, else 0	1.2214*** (0.3787)	0.0912 (0.2115)	-0.2872 (0.3530)	0.3819 (0.2407)	0.1532 (0.1889)	-0.8200*** (0.2248)
Pseudo R²	0.6624	0.7559	0.6755	0.7417	0.6088	0.5884

Notes: Robust standard errors in parentheses below coefficient estimates. N = 4296. Significance levels: ^ 0.10, * 0.05, ** 0.01, ***0.001
1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Technology articles & patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.
2. Knowledge stocks are computed as a perpetual inventory of the indicated series with 20% depreciation applied to the prior year's stock.

Table 6. Non-University Patenting by Science & Technology Areas – Poisson Regressions
Top-25 Science & Technology Countries, 1981-2004

Explanatory Variables	Science and Technology Areas of Patents					
	Bio/Chem/Med	Computing/IT	Nanotechnology	Semiconductors	Other Sciences	Other Engineering
Star Scientists & Engineers Active in Country in Same S&T Area as Patent	0.0031***	-0.0045	0.0342***	0.0010	0.0032	0.0023
	(0.0003)	(0.0041)	(0.0077)	(0.0032)	(0.0069)	(0.0090)
High Impact Articles Knowledge Stock in Same S&T Area as Patent	-0.0029***	-0.0062*	-0.0010	-0.0070***	-0.0038***	-0.0060**
	(0.0002)	(0.0027)	(0.0028)	(0.0020)	(0.0011)	(0.0023)
University Articles Knowledge Stock in Same S&T Area as Patent	0.0000***	0.0004***	0.0006***	0.0001***	0.0003***	0.0005***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0001)
University Patents Knowledge Stock in Same S&T Area as Patent	-0.0014***	-0.0079***	-0.0034***	-0.0083***	-0.0037***	-0.0022***
	(0.0001)	(0.0015)	(0.0003)	(0.0013)	(0.0006)	(0.0004)
Total Employment in Country (millions of persons)	-0.0013***	-0.0011^	-0.0025***	-0.0035***	-0.0002	-0.0003
	(0.0003)	(0.0006)	(0.0007)	(0.0006)	(0.0003)	(0.0004)
Constant	5.1431***	4.4491***	4.0109***	3.4846***	4.5586***	6.6587***
	(0.0629)	(0.1347)	(0.1162)	(0.1289)	(0.1096)	(0.1061)
Dummy = 1 in 2002, else 0	0.0967	0.0246	-0.3698^	0.3867^	0.2958	0.2709
	(0.1551)	(0.2940)	(0.1900)	(0.2031)	(0.2954)	(0.2930)
Dummy = 1 in 2003, else 0	-0.0804	0.8971^	-1.0543**	0.5924*	0.1549	0.1851
	(0.1139)	(0.4911)	(0.3415)	(0.2358)	(0.3737)	(0.3179)
Dummy = 1 in 2004, else 0	-2.5380***	0.2418	-0.9656**	0.3219	-0.6482	-0.2391
	(0.4526)	(0.4151)	(0.3458)	(0.2811)	(0.7875)	(0.3688)
Pseudo R²	0.8622	0.6993	0.8014	0.7252	0.6370	0.6513

Notes: Robust standard errors in parentheses below coefficient estimates. N = 600. Significance levels: ^ 0.10, * 0.05, ** 0.01, ***0.001
1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Technology articles & patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.
2. Knowledge stocks are computed as a perpetual inventory of the indicated series with 20% depreciation applied to the prior year's stock.

Table 7. Non-University Patenting by Science & Technology Areas – Poisson Regressions
Top-24 Non-U.S. Science & Technology Countries, 1981-2004

Explanatory Variables	Science and Technology Areas of Patents					
	Bio/Chem/Med	Computing/IT	Nanotechnology	Semiconductors	Other Sciences	Other Engineering
Star Scientists & Engineers Active in Country in Same S&T Area as Patent	0.0118***	-0.0637***	-0.0244	0.0431**	-0.1912***	-0.1309*
	(0.0019)	(0.0151)	(0.0315)	(0.0157)	(0.0213)	(0.0520)
High Impact Articles Knowledge Stock in Same S&T Area as Patent	-0.0036***	-0.0253***	0.0063	-0.0205*	0.0143***	-0.0099
	(0.0007)	(0.0057)	(0.0075)	(0.0090)	(0.0039)	(0.0142)
University Articles Knowledge Stock in Same S&T Area as Patent	0.0000***	0.0007***	0.0006***	0.0002***	0.0006***	0.0010***
	(0.0000)	(0.0001)	(0.0000)	(0.0000)	(0.0001)	(0.0001)
University Patents Knowledge Stock in Same S&T Area as Patent	-0.0090***	0.0658***	0.0116***	0.0406***	-0.0110	0.0006
	(0.0013)	(0.0101)	(0.0012)	(0.0063)	(0.0110)	(0.0047)
Total Employment in Country (millions of persons)	-0.0013***	-0.0029***	-0.0032***	-0.0042***	-0.0017***	-0.0016***
	(0.0003)	(0.0006)	(0.0008)	(0.0009)	(0.0004)	(0.0004)
Constant	4.6216***	4.2897***	3.8359***	3.1383****	4.0743***	6.5280***
	(0.0636)	(0.1406)	(0.1071)	(0.1996)	(0.1078)	(0.0871)
Dummy = 1 in 2002, else 0	0.1375	-0.6026**	-0.5678*	0.1328	0.0284	-0.4112
	(0.1261)	(0.2231)	(0.2308)	(0.3038)	(0.1931)	(0.3394)
Dummy = 1 in 2003, else 0	0.1252	0.1305	-0.9598***	0.2010	-0.0257	-0.5316
	(0.1320)	(0.3270)	(0.2692)	(0.3270)	(0.2044)	(0.3505)
Dummy = 1 in 2004, else 0	-0.4003**	-0.7148*	-0.9361***	-0.7544^	0.2681	-0.6360
	(0.1372)	(0.2900)	(0.2310)	(0.3863)	(0.2589)	(0.3931)
Pseudo R²	0.7355	0.6380	0.7380	0.6687	0.5359	0.4184

Notes: Robust standard errors in parentheses below coefficient estimates. N = 576. Significance levels: ^ 0.10, * 0.05, ** 0.01, ***0.001
  1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Tech-nology articles & patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.
  2. Knowledge stocks are computed as a perpetual inventory of the indicated series with 20% depreciation applied to the prior year's stock.

Table 8. Correlation Coefficients for the Levels and Growth Rates of Star Scientists & Engineers and Knowledge Stocks

	Correlation Coefficients of Level and Growth Rate across Years and Regions/Countries by S&T Field						
	All Sci. & Eng.	Bio/Chem/Med	Computing/IT	Nanotechnology	Semiconductors	Other Sciences	Other Engineering
US Regions							
Star Scientists & Eng.	0.06**	0.07***	0.13***	0.26***	0.11***	0.15***	0.23***
High Impact Articles	-0.02	-0.02	-0.04	-0.02	-0.03	-0.02	-0.03
University Articles	-0.01	-0.01	-0.06*	-0.09**	-0.01	-0.05*	-0.04^
University Patents	-0.03	-0.03	-0.00	-0.02	-0.01	-0.03	-0.03
Top-25 S&T Countries							
Star Scientists & Eng.	0.01	0.01	0.02	0.10^	0.02	0.03	0.05
High Impact Articles	-0.09*	-0.07^	-0.06	-0.08	-0.05	-0.05	-0.04
University Articles	-0.09*	-0.08^	-0.08*	-0.19***	-0.11**	-0.02	-0.04
University Patents	-0.03	-0.03	-0.01	-0.04	-0.02	-0.03	-0.01
Top-24 Non-US S&T Countries							
Star Scientists & Eng.	0.05	0.05	0.11*	0.26***	0.13***	0.13*	0.22***
High Impact Articles	-0.17***	-0.14***	-0.02	-0.13*	-0.09*	-0.10*	-0.08^
University Articles	-0.17***	-0.15***	-0.14***	-0.24***	-0.16***	-0.03	-0.07^
University Patents	-0.04	-0.05	-0.01	0.00	0.00	-0.03	-0.02

Notes: Significance levels: ^ 0.10, * 0.05, ** 0.01, ***0.001

1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Technology articles and patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.

Table A.1. Science-Area Concordance: Doctoral Programs, Web of Science Subject Categories & International Patent Codes

Darby-Zucker (1999) Area Name	Corresponding NRC (1995) Doctoral Programs	Corresponding Web of Science Subject Category Codes	Corresponding International Patent Classes
Biology, Chemistry, & Medicine	Biochemistry & Molecular Biology Cell & Developmental Biology Molecular & General Genetics Ecology, Evolution & Behavioral Biomedical Engineering Pharmacology Chemistry Neurosciences Physiology Chemical Engineering	AD,AE,AF,AH,AK,AM,AQ,AY,AZ,BA,BD,CN,CO, CQ,CU,CX,DA,DB,DE,DM,DQ,DR,DS,DW,DX,DY, EA,EC,EE,EI,EY,FF,FI,FQ,FY,GA,GM,GU,HB, HE,HL,HQ,HT,HY,IA,IG,IH,II,IY,JA,JY,KA,KI,KM, LI,LJ,LQ,MA,MU,NE,NI,NN,OI,OO,OP,PT,PW, PY,QA,QB,QU,RQ,RT,RU,RX,RZ,SA,SD,SU,TA, TC,TD,TI,TM,TQ,TU,UH,UM,UY,VE,VY,WC,WE, WF,WH,WV,XE,XW,YA,YO,YP,YU,ZA,ZC,ZD, ZE,ZM,ZR	A 61 B,A 61 C,A 61 D,A 61 F,A 61 G,A 61 H,A 61 J,A 61 K,A 61 L,A 61 M, A 61 N,A 61 P,B 01 J,B 01 L,C 01 B,C 01 C,C 01 D,C 01 F,C 01 G,C 02 F, C 03 B,C 03 C,C 04 B,C 05 B,C 05 C,C 05 D,C 05 F,C 05 G,C 06 B,C 06 C, C 06 D,C 06 F,C 07 B,C 07 C,C 07 D,C 07 F,C 07 G,C 07 H,C 07 J,C 07 K, C 07 M,C 08 B,C 08 C,C 08 F,C 08 G,C 08 H,C 08 J,C 08 K,C 08 L,C 09 B, C 09 C,C 09 D,C 09 F,C 09 G,C 09 H,C 09 J,C 09 K,C 10 B,C 10 C,C 10 F, C 10 G,C 10 H,C 10 J,C 10 K,C 10 L,C 10 M,C 10 N,C 11 B,C 11 C,C 11 D, C 12 C,C 12 F,C 12 G,C 12 H,C 12 J,C 12 L,C 12 M,C 12 N,C 12 P,C 12 Q, C 12 R,C 12 S,C 13 C,C 13 D,C 13 F,C 13 G,C 13 H,C 13 J,C 13 K,C 14 B, C 14 C
Computing & Information Technology	Computer Sciences Mathematics	AC,EP,ER,ES,ET,EV,EW, EX,PE,PN,PQ,RB,XY,YE	G 06 C,G 06 D,G 06 E,G 06 F,G 06 G,G 06 J,G 06 K,G 06 N,G 06 T, G 09 C,G 11 B,G 11 C
Semiconductors Integrated Circuits, High-temperature Superconductors	Physics Electrical Engineering Materials Science Mechanical Engineering	AA,DT,IQ,IU,PJ,PK,PM, PU,PZ,QF,QG,QH,QJ, QM,SR,SY,UB,UE,UF, UI,UK,UN,UP,UR,XQ,ZI	H 01 L
Other Sciences	Oceanography Astrophysics/Astronomy Statistics/Biostatistics Geosciences	GC,ID,JU,KV,KY,LE, OU,PI,QE,QQ,RA,RE, RO,SI,TE	C 30 B,G 01 B,G 01 C,G 01 D,G 01 F,G 01 G,G 01 H,G 01 J,G 01 K, G 01 L,G 01 M,G 01 N,G 01 P,G 01 R,G 01 S,G 01 T,G 01 V,G 01 W, G 02 B,G 02 C,G 02 F,G 21 B,G 21 C,G 21 D,G 21 F,G 21 G,G 21 H, G 21 J,G 21 K,H 01 S
Other Engineering	Aerospace Engineering Civil Engineering Industrial Engineering	AI,BU,FA,IF,IJ,IK,IL,IM, IO,IP,IX,OA,RY,YR,ZQ	All others — see note for current list.

Note: International Patent Classes corresponding to Other Engineering: A 01 B,A 01 C,A 01 D,A 01 F,A 01 G,A 01 H,A 01 J,A 01 K,A 01 L,A 01 M,A 01 N,A 21 B,A 21 C,A 21 D,A 22 B,
A 22 C,A 23 B,A 23 C,A 23 D,A 23 F,A 23 G,A 23 J,A 23 K,A 23 L,A 23 N,A 23 P,A 24 B,A 24 C,A 24 D,A 24 F,A 41 B,A 41 C,A 41 D,A 41 F,A 41 G,A 41 H,A 42 B,A 42 C,
A 43 B,A 43 C,A 43 D,A 44 B,A 44 C,A 45 B,A 45 C,A 45 D,A 45 F,A 46 B,A 46 D,A 47 B,A 47 C,A 47 D,A 47 F,A 47 G,A 47 H,A 47 J,A 47 K,A 47 L,A 62 B,A 62 C,A 62 D,
A 63 B,A 63 C,A 63 D,A 63 F,A 63 G,A 63 H,A 63 J,A 63 K,B 01 B,B 01 D,B 01 F,B 02 B,B 02 C,B 03 B,B 03 C,B 03 D,B 04 B,B 04 C,B 05 B,B 05 C,B 05 D,B 06 B,B 07 B,
B 07 C,B 08 B,B 09 B,B 09 C,B 21 B,B 21 C,B 21 D,B 21 F,B 21 G,B 21 H,B 21 J,B 21 K,B 21 L,B 22 C,B 22 D,B 22 F,B 23 B,B 23 C,B 23 D,B 23 F,B 23 G,B 23 H,B 23 K,
B 23 P,B 23 Q,B 24 B,B 24 C,B 24 D,B 25 B,B 25 C,B 25 D,B 25 F,B 25 G,B 25 H,B 25 J,B 26 B,B 26 D,B 26 F,B 27 B,B 27 C,B 27 D,B 27 F,B 27 G,B 27 H,B 27 J,B 27 K,
B 27 L,B 27 M,B 27 B,B 27 N,B 28 B,B 28 C,B 28 D,B 29 B,B 29 C,B 29 D,B 29 K,B 29 L,B 30 B,B 31 B,B 31 C,B 31 D,B 31 F,B 32 B,B 41 B,B 41 C,B 41 D,B 41 F,B 41 G,
B 41 J,B 41 K,B 41 L,B 41 M,B 41 N,B 42 B,B 42 C,B 42 F,B 43 K,B 43 L,B 43 M,B 44 B,B 44 C,B 44 D,B 60 B,B 60 C,B 60 D,B 60 G,B 60 H,B 60 J,
B 60 K,B 60 L,B 60 M,B 60 N,B 60 P,B 60 Q,B 60 R,B 60 S,B 60 T,B 60 V,B 61 B,B 61 C,B 61 D,B 61 F,B 61 G,B 61 H,B 61 J,B 61 K,B 61 L,B 62 B,B 62 C,B 62 D,B 62 H,
B 62 J,B 62 K,B 62 L,B 62 M,B 63 B,B 63 C,B 63 G,B 63 H,B 63 J,B 64 B,B 64 C,B 64 D,B 64 F,B 64 G,B 65 B,B 65 C,B 65 D,B 65 F,B 65 G,B 65 H,B 66 B,B 66 C,B 66 D,
B 66 F,B 67 B,B 67 C,B 67 D,B 68 B,B 68 C,B 68 F,B 68 G,B 81 B,B 81 C,B 82 B,C 21 B,C 21 C,C 21 D,C 22 B,C 22 C,C 22 F,C 22 K,C 23 C,C 23 D,C 23 F,C 23 G,C 25 B,
C 25 C,C 25 D,C 25 F,D 01 B,D 01 C,D 01 D,D 01 F,D 01 G,D 01 H,D 02 G,D 02 H,D 02 J,D 03 C,D 03 D,D 03 J,D 04 B,D 04 C,D 04 D,D 04 G,D 04 H,D 05 B,D 05 C,D 06 B,
D 06 C,D 06 F,D 06 G,D 06 H,D 06 J,D 06 L,D 06 M,D 06 N,D 06 P,D 06 Q,D 07 B,D 21 B,D 21 C,D 21 D,D 21 F,D 21 G,D 21 H,D 21 J,E 01 B,E 01 C,E 01 D,E 01 F,E 01 H,
E 02 B,E 02 C,E 02 D,E 02 F,E 03 B,E 03 C,E 03 D,E 03 F,E 04 B,E 04 C,E 04 D,E 04 F,E 04 G,E 04 H,E 05 B,E 05 C,E 05 D,E 05 F,E 05 G,E 06 B,E 06 C,E 21 B,E 21 C,
E 21 D,E 21 F,F 01 B,F 01 C,F 01 D,F 01 K,F 01 L,F 01 M,F 01 N,F 01 P,F 02 B,F 02 C,F 02 D,F 02 F,F 02 G,F 02 K,F 02 M,F 02 N,F 02 P,F 03 B,F 03 C,F 03 D,F 03 G,F 03 H,
F 04 B,F 04 C,F 04 D,F 04 F,F 15 B,F 15 C,F 15 D,F 16 B,F 16 C,F 16 D,F 16 F,F 16 G,F 16 H,F 16 J,F 16 K,F 16 L,F 16 M,F 16 N,F 16 P,F 16 S,F 16 T,F 17 B,F 17 C,F 17 D,
F 21 H,F 21 K,F 21 L,F 21 S,F 21 V,F 21 W,F 21 Y,F 22 B,F 22 D,F 22 G,F 23 B,F 23 C,F 23 D,F 23 G,F 23 H,F 23 J,F 23 K,F 23 L,F 23 M,F 23 N,F 23 Q,F 23 R,F 24 B,F 24 C,
F 24 D,F 24 F,F 24 H,F 24 J,F 25 B,F 25 C,F 25 D,F 25 J,F 26 B,F 27 B,F 27 D,F 28 B,F 28 C,F 28 D,F 28 F,F 28 G,F 41 A,F 41 B,F 41 C,F 41 F,F 41 G,F 41 H,F 41 J,F 42 B,
F 42 C,F 42 D,G 03 B,G 03 C,G 03 D,G 03 F,G 03 G,G 03 H,G 04 B,G 04 C,G 04 D,G 04 F,G 04 G,G 05 B,G 05 D,G 05 F,G 05 G,G 07 B,G 07 C,G 07 D,G 07 F,G 07 G,
G 08 B,G 08 C,G 08 G,G 09 B,G 09 D,G 09 F,G 09 G,G 10 B,G 10 C,G 10 D,G 10 F,G 10 G,G 10 H,G 10 K,G 10 L,H 01 B,H 01 C,H 01 F,H 01 G,H 01 H,H 01 J,H 01 K,
H 01 M,H 01 P,H 01 Q,H 01 R,H 01 T,H 02 B,H 02 G,H 02 H,H 02 J,H 02 K,H 02 M,H 02 N,H 02 P,H 03 B,H 03 C,H 03 D,H 03 F,H 03 G,H 03 H,H 03 J,H 03 K,H 03 L,H 03 M,
H 04 B,H 04 H,H 04 J,H 04 K,H 04 L,H 04 M,H 04 N,H 04 Q,H 04 R,H 04 S,H 05 B,H 05 C,H 05 F,H 05 G,H 05 H

Table A.2. Firm Entry into New Technologies – Only First 1,838 Stars Used for Analysis
Poisson Regressions – U.S. Functional Economic Regions, 1981-2004

Explanatory Variables	Science and Technology Areas of Firm Entry					
	Bio/Chem/Med	Computing/IT	Nanotechnology	Semiconductors	Other Sciences	Other Engineering
Star Scientists & Engineers Active in Region/ Country in Same S&T Area as Entry	0.0194*** (0.0016)	0.0384** (0.0131)	0.1281*** (0.0287)	0.0450*** (0.0083)	0.0493*** (0.0083)	0.1326*** (0.0135)
High Impact Articles Knowledge Stock in Same S&T Area as Entry	-0.0026*** (0.0006)	0.0265*** (0.0038)	0.0355^ (0.0199)	0.0256*** (0.0061)	0.0049*** (0.0011)	-0.0373*** (0.0061)
University Articles Knowledge Stock in Same S&T Area as Entry	0.0000*** (0.0000)	-0.0014*** (0.0002)	-0.0003 (0.0007)	-0.0007*** (0.0001)	-0.0007*** (0.0001)	0.0017*** (0.0004)
University Patents Knowledge Stock in Same S&T Area as Entry	-0.0047*** (0.0008)	-0.0022 (0.0081)	-0.0077^ (0.0199)	0.0332*** (0.0096)	0.0045* (0.0021)	-0.0068^ (0.0028)
Total Employment in Region/Country (millions of persons)	0.0860*** (0.0173)	0.1441*** (0.0218)	0.0664** (-0.0235)	0.1249*** (0.0208)	0.1832*** (0.0194)	0.1252*** (0.0186)
Average Wage per Job in Region (thousands of 2000 dollars)	0.1308*** (0.0074)	0.1792*** (0.0092)	0.2003*** (0.0097)	0.1439*** (0.0280)	0.1159*** (0.0083)	0.1259*** (0.0066)
Constant	-1.9523*** (0.1940)	-4.1337*** (0.2392)	-5.1485*** (0.2597)	-3.2997*** (0.2220)	-2.2145*** (0.2218)	-1.1115*** (0.1743)
Dummy = 1 in 2002, else 0	-0.8262*** (0.1109)	-0.9165*** (0.1049)	-0.7597*** (0.1153)	-0.6797*** (0.1054)	-0.9421*** (0.1379)	-1.0670*** (0.1008)
Dummy = 1 in 2003, else 0	-1.2677*** (0.1116)	-1.5988*** (0.1234)	-1.5156*** (0.1267)	-0.8646*** (0.1097)	-1.2416*** (0.1185)	-1.7126*** (0.1113)
Dummy = 1 in 2004, else 0	-2.0592*** (0.1431)	-2.3893*** (0.1293)	-2.7683*** (0.1986)	-1.5379*** (0.1395)	-2.2576*** (0.1370)	-3.1119*** (0.1432)
Pseudo R²	0.6261	0.5827	0.5374	0.5348	0.5303	0.5938

Notes: Robust standard errors in parentheses below coefficient estimates. N = 4296. Significance levels: ^ 0.10, * 0.05, ** 0.01, ***0.001
1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Technology articles & patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.
2. Knowledge stocks are computed as a perpetual inventory of the indicated series with 20% depreciation applied to the prior year's stock.

Explanatory Variables	Science and Technology Areas of Firm Entry					
	Bio/Chem/Med	Computing/IT	Nanotechnology	Semiconductors	Other Sciences	Other Engineering
Star Scientists & Engineers Active in Region/ Country in Same S&T Area as Entry	0.0068*** (0.0005)	0.0360*** (0.0040)	0.0924*** (0.0097)	0.0180* (0.0079)	0.0354*** (0.0057)	0.0584*** (0.0131)
High Impact Articles Knowledge Stock in Same S&T Area as Entry	-0.0020*** (0.0002)	-0.0072*** (0.0016)	-0.0004 (0.0080)	-0.0032 (0.0028)	-0.0030*** (0.0008)	-0.0077^ (0.0041)
University Articles Knowledge Stock in Same S&T Area as Entry	0.0000*** (0.0000)	0.0002*** (0.0000)	0.0003** (0.0001)	0.0000* (0.0000)	0.0002*** (0.0001)	0.0004*** (0.0001)
University Patents Knowledge Stock in Same S&T Area as Entry	-0.0008*** (0.0001)	-0.0031* (0.0014)	-0.0017* (0.0008)	-0.0007 (0.0033)	-0.0035*** (0.0006)	-0.0014** (0.0004)
Total Employment in Region/Country (millions of persons)	-0.0000*** (0.0000)	-0.0000** (0.0000)	0.0000 (0.0000)	.0000 (0.0000)	-0.0000* (0.0000)	-0.0000 (0.0000)
Constant	2.5835*** (0.0570)	1.5148*** (0.0699)	1.3556*** (0.1291)	2.1523*** (0.1253)	1.7004*** (0.1065)	2.8651*** (0.0957)
Dummy = 1 in 2002, else 0	-0.1754 (0.1161)	-0.4546** (0.2045)	-1.0613*** (0.2164)	0.1913 (0.1795)	-0.5989** (0.2042)	-0.8596*** (0.1729)
Dummy = 1 in 2003, else 0	-0.2512 (0.1555)	0.5873** (0.2083)	-2.0177*** (0.3995)	0.2526 (0.1894)	-1.1576*** (0.2859)	-1.2735*** (0.1375)
Dummy = 1 in 2004, else 0	-2.0691*** (0.5343)	-0.9691*** (0.2637)	-2.5840^ (1.3294)	0.3677 (0.2937)	-2.5481*** (0.5378)	-2.4954*** (0.4110)
Pseudo R²	0.8803	0.8732	0.7604	0.7701	0.8690	0.8690

Notes: Robust standard errors in parentheses below coefficient estimates. N = 600. Significance levels: ^ 0.10, * 0.05, ** 0.01, ***0.001
1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Technology articles & patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.
2. Knowledge stocks are computed as a perpetual inventory of the indicated series with 20% depreciation applied to the prior year's stock.

Table A.4. Firm Entry into New Technologies – Only First 1,838 Stars Used for Analysis
Poisson Regressions – Top-24 Non-U.S. Science & Technology Countries, 1981-2004

Explanatory Variables	Science and Technology Areas of Firm Entry					
	Bio/Chem/Med	Computing/IT	Nanotechnology	Semiconductors	Other Sciences	Other Engineering
Star Scientists & Engineers Active in Region/ Country in Same S&T Area as Entry	0.0174*** (0.0033)	0.0467** (0.0151)	0.0445 (0.0364)	0.0450** (0.0189)	0.0165 (0.0249)	-0.0083 (0.0324)
High Impact Articles Knowledge Stock in Same S&T Area as Entry	-0.0015* (0.0007)	-0.0040 (0.0033)	0.0340*** (0.0090)	0.0132*** (0.0028)	0.0017 (0.0027)	0.0155** (0.0058)
University Articles Knowledge Stock in Same S&T Area as Entry	0.0000*** (0.0000)	0.0003*** (0.0000)	-0.0000 (0.0001)	0.0000*** (0.0000)	0.0003*** (0.0001)	0.0001 (0.0001)
University Patents Knowledge Stock in Same S&T Area as Entry	0.0011 (0.0008)	0.0021 (0.0101)	0.0136*** (0.0020)	-0.0057 (0.0067)	-0.0156* (0.0076)	0.0105*** (0.0023)
Total Employment in Region/Country (millions of persons)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000^ (0.0000)	-0.0000^ (0.0000)	-0.0000* (0.0000)	-0.0000^ (0.0000)
Constant	2.3409*** (0.0445)	1.0949*** (0.6406)	1.1505*** (0.0642)	1.2966*** (0.0586)	1.5624*** (0.0599)	2.8987*** (0.0630)
Dummy = 1 in 2002, else 0	-0.2373^ (0.1443)	-0.5619*** (0.1669)	-0.9431*** (0.2465)	0.2295* (0.1015)	-0.0608 (0.1563)	-0.9973*** (0.2861)
Dummy = 1 in 2003, else 0	-0.3317* (0.1499)	-0.6279** (0.2163)	-1.5847*** (0.2483)	0.0374 (0.1377)	-0.5147** (0.1767)	-1.400*** (0.2524)
Dummy = 1 in 2004, else 0	-0.8708*** (0.1706)	-1.4681*** (0.2600)	-1.8348*** (0.3138)	-0.1053 (0.1133)	-1.0134*** (0.2556)	-2.1298*** (0.2105)
Pseudo R²	0.5879	0.4592	0.4377	0.5081	0.4444	0.4568

Notes: Robust standard errors in parentheses below coefficient estimates. N =576 . Significance levels: ^ 0.10, * 0.05, ** 0.01, ***0.001
   1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Technology articles & patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.
   2. Knowledge stocks are computed as a perpetual inventory of the indicated series with 20% depreciation applied to the prior year's stock.

Table A.5. Non-University Patenting by Science & Technology Areas – Only First 1,838 Stars Used for Analysis
Poisson Regressions – U.S. Functional Economic Regions, 1981-2004

Explanatory Variables	Science and Technology Areas of Patents					
	Bio/Chem/Med	Computing/IT	Nanotechnology	Semiconductors	Other Sciences	Other Engineering
Star Scientists & Engineers Active in Region in Same S&T Area as Patent	0.0226*** (0.0042)	-0.1582*** (0.0305)	0.1585*** (0.0405)	0.0200 (0.0135)	-0.0263 (0.0270)	0.0796^ (0.0426)
High Impact Articles Knowledge Stock in Same S&T Area as Patent	-0.0064*** (0.0017)	0.0546*** (0.0053)	-0.0130 (0.0170)	0.0138* (0.0062)	0.0046*** (0.0012)	-0.0639*** (0.0085)
University Articles Knowledge Stock in Same S&T Area as Patent	0.0002*** (0.0000)	0.0005* (0.0002)	0.0026*** (0.0008)	0.0004* (0.0002)	0.0004^ (0.0002)	0.0058*** (0.0003)
University Patents Knowledge Stock in Same S&T Area as Patent	-0.0109*** (0.0015)	-0.0364*** (0.0074)	-0.0045 (0.0031)	0.0210* (0.0104)	0.0057^ (0.0034)	-0.0171*** (0.0017)
Total Employment in Region (millions of persons)	-0.2837** (0.1046)	-0.0542 (0.0675)	-0.1103** (0.0428)	-0.1401* (0.0663)	0.0080 (0.0938)	-0.0053 (0.0193)
Average Wage per Job in Region (thousands of 2000 dollars)	0.1722*** (0.0144)	0.2059*** (0.0221)	0.2129*** (0.0154)	0.1435*** (0.0210)	0.1031*** (0.0205)	0.1315*** (0.0115)
Constant	-1.8911*** (0.3744)	-3.5819*** (0.5818)	-4.2800*** (0.4182)	-3.3132*** (0.5369)	-0.9546^ (0.5063)	0.1305 (0.2944)
Dummy = 1 in 2002, else 0	-0.3273 (0.2408)	0.1145 (0.1771)	0.1363 (0.2007)	0.3506^ (0.2018)	-0.1984 (0.2020)	-0.2024 (0.1365)
Dummy = 1 in 2003, else 0	-0.6598^ (0.3402)	-0.5144* (0.2296)	-0.2590 (0.2690)	0.3504^ (0.2057)	-0.0527 (0.1812)	-0.2612^ (0.1411)
Dummy = 1 in 2004, else 0	-1.2569*** (0.3906)	0.1038 (0.1985)	-0.5283 (0.3984)	0.4015^ (0.2407)	-0.0652 (0.1769)	-0.9810*** (0.2522)
Pseudo R²	0.6616	0.7552	0.6853	0.7416	0.5953	0.5852

Notes: Robust standard errors in parentheses below coefficient estimates. N = 4296. Significance levels: ^ 0.10, * 0.05, ** 0.01, ***0.001
    1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Technology articles & patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.
    2. Knowledge stocks are computed as a perpetual inventory of the indicated series with 20% depreciation applied to the prior year's stock.

Table A.6. Non-University Patenting by Science & Technology Areas – Only First 1,838 Stars Used for Analysis
Poisson Regressions – Top-25 Science & Technology Countries, 1981-2004

Explanatory Variables	Science and Technology Areas of Patents					
	Bio/Chem/Med	Computing/IT	Nanotechnology	Semiconductors	Other Sciences	Other Engineering
Star Scientists & Engineers Active in Country in Same S&T Area as Patent	0.0058*** (0.0010)	0.0024 (0.0169)	0.0391*** (0.0111)	0.0040 (0.0041)	0.0093 (0.0099)	0.0443** (0.0151)
High Impact Articles Knowledge Stock in Same S&T Area as Patent	-0.0030*** (0.0003)	-0.0088^ (0.0050)	0.0024 (0.0024)	-0.0080*** (0.0018)	-0.0037*** (0.0010)	-0.0150*** (0.0042)
University Articles Knowledge Stock in Same S&T Area as Patent	0.0000*** (0.0000)	0.0003*** (0.0001)	0.0006*** (0.0000)	0.0002*** (0.0000)	0.0003*** (0.0001)	0.0006*** (0.0001)
University Patents Knowledge Stock in Same S&T Area as Patent	-0.0012*** (0.0001)	-0.0075*** (0.0019)	-0.0034*** (0.0003)	-0.0080*** (0.0013)	-0.0036*** (0.0006)	-0.0018*** (0.0004)
Total Employment in Country (millions of persons)	-0.0000*** (0.0000)	-0.0000* (0.0000)	-0.0000** (0.0000)	-0.0000*** (0.0000)	-0.0000 (0.0000)	-0.0000 (0.0000)
Constant	5.1655*** (0.0635)	4.4882*** (0.1466)	4.0602*** (0.1155)	3.4831*** (0.1282)	4.5652*** (0.1077)	6.6368*** (0.0828)
Dummy = 1 in 2002, else 0	0.0925 (0.1550)	0.0673 (0.3025)	-0.5232** (0.1760)	0.3815^ (0.2025)	0.2881 (0.2960)	0.2481 (0.2773)
Dummy = 1 in 2003, else 0	-0.0562 (0.1290)	1.2849** (0.4147)	-1.3249*** (0.3781)	0.5975* (0.2373)	0.1433 (0.3828)	0.2181 (0.3007)
Dummy = 1 in 2004, else 0	-2.5142*** (0.4673)	0.4673 (0.3993)	-1.0230** (0.3568)	0.2524 (0.2918)	-0.6716 (0.7999)	-0.7497 (0.5178)
Pseudo R²	0.8555	0.6969	0.7907	0.7264	0.6391	0.6697

Notes: Robust standard errors in parentheses below coefficient estimates. N = 600. Significance levels: ^ 0.10, * 0.05, ** 0.01, ***0.001
1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Tech-nology articles & patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.
2. Knowledge stocks are computed as a perpetual inventory of the indicated series with 20% depreciation applied to the prior year's stock.

Table A.7. Non-University Patenting by Science & Technology Areas – Only First 1,838 Stars Used for Analysis
Poisson Regressions – Top-24 Non-U.S. Science & Technology Countries, 1981-2004

Explanatory Variables	Science and Technology Areas of Patents					
	Bio/Chem/Med	Computing/IT	Nanotechnology	Semiconductors	Other Sciences	Other Engineering
Star Scientists & Engineers Active in Country in Same S&T Area as Patent	0.0183***	-0.1480***	-0.1675***	0.0288	-0.4189***	-0.4857***
	(0.0048)	(0.0334)	(0.0433)	(0.0322)	(0.0447)	(0.0577)
High Impact Articles Knowledge Stock in Same S&T Area as Patent	-0.0033***	-0.0265***	0.0195*	-0.0118	0.0173***	-0.0002
	(0.0010)	(0.0058)	(0.0083)	(0.0090)	(0.0041)	(0.0060)
University Articles Knowledge Stock in Same S&T Area as Patent	0.0000***	0.0006***	0.0005***	0.0002***	0.0004***	0.0010***
	(0.0000)	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)
University Patents Knowledge Stock in Same S&T Area as Patent	-0.0059***	0.0674***	0.0119***	0.0405***	-0.0254*	0.0028
	(0.0013)	(0.0105)	(0.0011)	(0.0064)	(0.0129)	(0.0035)
Total Employment in Country (millions of persons)	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000*	-0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Constant	4.6568***	4.2791***	3.8805***	3.1278***	4.1023***	6.3986***
	(0.0694)	(0.1364)	(0.1135)	(0.2031)	(0.1144)	(0.0945)
Dummy = 1 in 2002, else 0	-0.0088	-0.5639**	-0.5674*	0.0269	0.0433	-0.5582**
	(0.1281)	(0.2158)	(0.2406)	(0.3043)	(0.1946)	(0.2041)
Dummy = 1 in 2003, else 0	-0.0416	0.2446	-1.0276***	-0.0374	0.0836	-0.7308***
	(0.1354)	(0.3250)	(0.2836)	(0.3210)	(0.2237)	(0.2227)
Dummy = 1 in 2004, else 0	-0.5367***	-0.5884*	-0.8100***	-0.8070*	0.4740^	-0.7051**
	(0.1254)	(0.2782)	(0.2168)	(0.3971)	(0.2791)	(0.2541)
Pseudo R²	0.7234	0.6419	0.7492	0.6634	0.5465	0.5230

Notes: Robust standard errors in parentheses below coefficient estimates. N = 576. Significance levels: ^ 0.10, * 0.05, ** 0.01, ***0.001
1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Technology articles & patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.
2. Knowledge stocks are computed as a perpetual inventory of the indicated series with 20% depreciation applied to the prior year's stock.

Table A.8. Summary Statistics for Variables Used in Empirical Analysis Based on Only First 1,838 Stars, 1981-2004

Variables	U.S. Regions					Top-25 Sci. & Tech Countries					Top-24 non-U.S S&T Countries				
	N	Mean	S.D.	Min	Max	N	Mean	S.D.	Min	Max	N	Mean	S.D.	Min	Max
Entry of Firms into:															
Biology/Chemistry/Medicine	4296	7.2	15.9	0	165	600	45.8	149.4	0	1067	576	21.8	24.9	0	125
Computing/Information Technology	4296	3.2	9.8	0	203	600	20.7	80.5	0	738	576	7.3	10.3	0	56
Nanotechnology	4296	1.9	6.2	0	87	600	12.5	53.5	0	483	576	5.4	9.7	0	71
Semiconductors	4296	2.7	7.3	0	90	600	24.5	80.7	0	657	576	9.3	12.2	0	73
Other Sciences	4296	3.6	8.3	0	104	600	24.5	89.0	0	609	576	9.5	13.5	0	66
Other Engineering	4296	12.8	24.7	0	248	600	72.8	287.0	0	2107	576	29.6	42.3	0	207
Non-university patenting:															
Biology/Chemistry/Medicine	4296	30.6	147.7	0	1986.4	600	729.8	2081.8	0	14783.0	576	344.7	663.8	0	4079.3
Computing/Information Technology	4296	20.4	165.2	0	4130.3	600	446.5	1709.5	0	14101.2	576	214.9	828.1	0	9188.5
Nanotechnology	4296	9.8	73.7	0	2089.8	600	247.8	966.5	0	8245.5	576	141.2	625.5	0	7967.5
Semiconductors	4296	5.4	46.7	0	1126.7	600	162.1	544.0	0	4453.6	576	96.1	347.4	0	3039.5
Other Sciences	4296	11.1	50.4	0	946.4	600	311.7	881.2	0	6453.9	576	164.3	446.2	0	4102.3
Other Engineering	4296	71.9	262.1	0	3422.7	600	2286.5	6261.7	0	41986.1	576	1241.1	3133.4	0	23161.3
Star Scientists & Engineers Active															
Biology/Chemistry/Medicine	4296	5.0	15.3	0	121	600	57.1	186.8	0	1140	576	19.6	26.0	0	130
Computing/Information Technology	4296	0.8	3.0	0	30	600	8.2	28.0	0	169	576	2.6	3.4	0	17
Nanotechnology	4296	0.2	0.9	0	12	600	2.0	7.2	0	58	576	0.8	1.7	0	10
Semiconductors	4296	1.1	3.8	0	43	600	11.2	40.7	0	270	576	3.1	3.3	0	19
Other Sciences	4296	0.6	2.4	0	26	600	6.3	21.5	0	132	576	2.0	3.3	0	17
Other Engineering	4296	0.3	1.2	0	11	600	3.3	11.6	0	76	576	1.0	1.8	0	11
High Impact Articles Knowledge Stock															
Biology/Chemistry/Medicine	4296	13.1	55.0	0	518.9	600	277.3	834.2	0	4,911.6	576	115.0	156.2	0	870.3
Computing/Information Technology	4296	2.5	11.5	0	123.5	600	58.4	162.4	0	1,194.3	576	27.0	34.6	0	248.2
Nanotechnology	4296	0.5	2.9	0	65.9	600	15.1	53.7	0	513.1	576	7.6	14.4	0	96.9
Semiconductors	4296	2.0	9.7	0	115.4	600	53.4	146.1	0	907.9	576	25.3	32.0	0	137.1
Other Sciences	4296	5.0	25.1	0	246.0	600	96.7	324.2	0	1,994.1	576	34.7	52.6	0	269.4
Other Engineering	4296	1.3	7.3	0	75.2	600	30.4	91.2	0	528.3	576	12.6	18.7	0	103.4
University Articles Knowledge Stock															
Biology/Chemistry/Medicine	4296	1485.0	5068.2	0	61,361.2	600	46272.6	108860.9	64.0	729,673.6	576	26210.2	31255.5	64.0	159,973.2
Computing/Information Technology	4296	90.9	317.1	0	3,803.9	600	3501.5	7268.2	6.0	49,950.6	576	2207.5	2476.7	6.0	12,449.2
Nanotechnology	4296	20.0	94.2	0	1,509.7	600	953.9	2557.6	0	24,685.3	576	654.0	1338.9	0	9,289.5
Semiconductors	4296	159.7	577.8	0	6,030.3	600	7438.5	13386.2	24.4	81,232.2	576	5198.3	6455.8	24.4	36,102.0
Other Sciences	4296	99.7	374.2	0	4,161.1	600	3245.2	7703.8	3	48,111.6	576	1816.8	2207.4	3	11,874.8
Other Engineering	4296	44.0	158.6	0	1,691.6	600	1534.7	3622.9	1	23,672.5	576	875.5	1166.2	1	7,241.4
University Patents Knowledge Stock															
Biology/Chemistry/Medicine	4296	8.7	40.4	0	564.3	600	134.7	672.2	0	5259.8	576	17.4	37.4	0	262.0
Computing/Information Technology	4296	0.7	3.9	0	66.6	600	11.3	61.0	0	576.3	576	1.3	3.6	0	35.5
Nanotechnology	4296	3.3	21.7	0	415.8	600	53.5	334.6	0	3599.1	576	6.3	18.0	0	237.4
Semiconductors	4296	0.3	2.4	0	44.5	600	5.8	28.5	0	294.8	576	0.8	4.4	0	92.8
Other Sciences	4296	2.2	12.3	0	224.4	600	34.8	163.4	0	1281.0	576	4.7	10.4	0	58.9
Other Engineering	4296	3.4	15.3	0	255.8	600	62.1	291.6	0	2330.0	576	9.5	20.0	0	129.1
Total Employment in Region/Country	4296	0.8	1.4	0.0	12.9	600	47.3	123.3	1.0382	752	576	44.2	124.9	1.0	752.0
Average Wage per Job in Region	4296	26.2	4.1	18.3	51.0	—	—	—	—	—	—	—	—	—	—

Notes: 1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated
 Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Tech-
 nology articles & patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.
2. U.S. regions are the 179 functional economic areas defined by the U.S. Bureau of Economic Analysis (Johnson and Kort 2004).

Table B.1. Correlation Coefficients for Variables Used in Empirical Analysis, 1981-2004

SEMICONDUCTORS

U.S. Regions

	I	II	III	IV	V	VI	VII	VIII
I. Entry of Firms	1.00							
II. Non-universiy Patenting |	0.49	1.00						
III. Stars Scientists and Engineers Active	0.79	0.42	1.00					
IV. University Articles Knowledge Stock	0.58	0.61	0.64	1.00				
V. High Impact Articles Knowledge Stock	0.64	0.63	0.69	0.93	1.00			
VI. University Patents Knowledge Stock	0.40	0.64	0.34	0.60	0.57	1.00		
VII. Total Employment in Region/Country	0.78	0.39	0.83	0.58	0.57	0.31	1.00	
VIII. Average Wage per Job in Region	0.39	0.24	0.33	0.27	0.25	0.16	0.50	1.00

Top - 25 Sci & Tech. Countries

	I	II	III	IV	V	VI	VII
I. Entry of Firms	1.00						
II. Non-universiy Patenting |	0.57	1.00					
III. Stars Scientists and Engineers Active	0.93	0.60	1.00				
IV. University Articles Knowledge Stock	0.78	0.78	0.85	1.00			
V. High Impact Articles Knowledge Stock	0.88	0.65	0.97	0.92	1.00		
VI. University Patents Knowledge Stock	0.72	0.74	0.79	0.83	0.83	1.00	
VII. Total Employment in Region/Country	0.12	0.09	0.12	0.20	0.11	0.11	1.00

Top - 24 Non -US S&T Countries

	I	II	III	IV	V	VI	VII
I. Entry of Firms	1.00						
II. Non-universiy Patenting |	0.49	1.00					
III. Stars Scientists and Engineers Active	0.79	0.44	1.00				
IV. University Articles Knowledge Stock	0.74	0.62	0.70	1.00			
V. High Impact Articles Knowledge Stock	0.82	0.47	0.88	0.83	1.00		
VI. University Patents Knowledge Stock	0.12	0.35	0.09	0.25	0.14	1.00	
VII. Total Employment in Region/Country	-0.01	0.01	0.01	0.20	-0.03	0.02	1.00

NANOTECHNOLOGY

U.S. Regions

	I	II	III	IV	V	VI	VII	VIII
I. Entry of Firms	1.00							
II. Non-universiy Patenting |	0.51	1.00						
III. Stars Scientists and Engineers Active	0.71	0.57	1.00					
IV. University Articles Knowledge Stock	0.47	0.75	0.55	1.00				
V. High Impact Articles Knowledge Stock	0.50	0.83	0.56	0.90	1.00			
VI. University Patents Knowledge Stock	0.55	0.84	0.58	0.87	0.90	1.00		
VII. Total Employment in Region/Country	0.67	0.39	0.69	0.41	0.37	0.41	1.00	
VIII. Average Wage per Job in Region	0.38	0.26	0.33	0.21	0.22	0.22	0.50	1.00

Top - 25 Sci & Tech. Countries

	I	II	III	IV	V	VI	VII
I. Entry of Firms	1.00						
II. Non-universiy Patenting |	0.62	1.00					
III. Stars Scientists and Engineers Active	0.87	0.78	1.00				
IV. University Articles Knowledge Stock	0.63	0.82	0.83	1.00			
V. High Impact Articles Knowledge Stock	0.77	0.79	0.94	0.93	1.00		
VI. University Patents Knowledge Stock	0.70	0.74	0.88	0.87	0.96	1.00	
VII. Total Employment in Region/Country	0.10	0.09	0.11	0.18	0.11	0.09	1.00

Top - 24 Non -US S&T Countries

	I	II	III	IV	V	VI	VII
I. Entry of Firms	1.00						
II. Non-universiy Patenting |	0.51	1.00					
III. Stars Scientists and Engineers Active	0.70	0.42	1.00				
IV. University Articles Knowledge Stock	0.52	0.63	0.66	1.00			
V. High Impact Articles Knowledge Stock	0.67	0.50	0.84	0.88	1.00		
VI. University Patents Knowledge Stock	0.33	0.41	0.34	0.53	0.47	1.00	
VII. Total Employment in Region/Country	-0.01	0.02	0.02	0.21	0.07	-0.01	1.00

BIOLOGY/CHEMISTRY/MEDICINE

U.S. Regions

	I	II	III	IV	V	VI	VII	VIII
I. Entry of Firms	1.00							
II. Non-universiy Patenting |	0.60	1.00						
III. Stars Scientists and Engineers Active	0.72	0.60	1.00					
IV. University Articles Knowledge Stock	0.51	0.84	0.68	1.00				
V. High Impact Articles Knowledge Stock	0.53	0.74	0.77	0.92	1.00			
VI. University Patents Knowledge Stock	0.48	0.82	0.62	0.92	0.82	1.00		
VII. Total Employment in Region/Country	0.78	0.67	0.81	0.62	0.60	0.56	1.00	
VIII. Average Wage per Job in Region	0.38	0.31	0.39	0.29	0.28	0.28	0.50	1.00

Top - 25 Sci & Tech. Countries

	I	II	III	IV	V	VI	VII
I. Entry of Firms	1.00						
II. Non-universiy Patenting |	0.78	1.00					
III. Stars Scientists and Engineers Active	0.78	0.92	1.00				
IV. University Articles Knowledge Stock	0.68	0.93	0.93	1.00			
V. High Impact Articles Knowledge Stock	0.74	0.91	0.97	0.97	1.00		
VI. University Patents Knowledge Stock	0.63	0.89	0.86	0.93	0.90	1.00	
VII. Total Employment in Region/Country	0.08	0.11	0.11	0.11	0.10	0.11	1.00

Top - 24 Non -US S&T Countries

	I	II	III	IV	V	VI	VII
I. Entry of Firms	1.00						
II. Non-universiy Patenting |	0.63	1.00					
III. Stars Scientists and Engineers Active	0.67	0.57	1.00				
IV. University Articles Knowledge Stock	0.58	0.76	0.76	1.00			
V. High Impact Articles Knowledge Stock	0.63	0.52	0.94	0.82	1.00		
VI. University Patents Knowledge Stock	0.37	0.26	0.52	0.60	0.60	1.00	
VII. Total Employment in Region/Country	-0.07	-0.01	-0.09	-0.02	-0.10	-0.01	1.00

(continued)

Table B.1. Correlation Coefficients for Variables Used in Empirical Analysis, 1981-2004
(concluded)

OTHER SCIENCES

U.S. Regions

	I	II	III	IV	V	VI	VII	VIII
I. Entry of Firms	1.00							
II. Non-universiy Patenting |	0.48	1.00						
III. Stars Scientists and Engineers Active	0.57	0.51	1.00					
IV. University Articles Knowledge Stock	0.42	0.82	0.54	1.00				
V. High Impact Articles Knowledge Stock	0.43	0.77	0.57	0.91	1.00			
VI. University Patents Knowledge Stock	0.42	0.88	0.49	0.79	0.77	1.00		
VII. Total Employment in Region/Country	0.68	0.57	0.74	0.61	0.59	0.45	1.00	
VIII. Average Wage per Job in Region	0.33	0.32	0.34	0.28	0.27	0.24	0.50	1.00

Top - 25 Sci & Tech. Countries

	I	II	III	IV	V	VI	VII
I. Entry of Firms	1.00						
II. Non-universiy Patenting |	0.64	1.00					
III. Stars Scientists and Engineers Active	0.68	0.85	1.00				
IV. University Articles Knowledge Stock	0.63	0.84	0.95	1.00			
V. High Impact Articles Knowledge Stock	0.67	0.83	0.97	0.98	1.00		
VI. University Patents Knowledge Stock	0.62	0.84	0.92	0.94	0.94	1.00	
VII. Total Employment in Region/Country	0.07	0.11	0.12	0.13	0.11	0.11	1.00

Top - 24 Non -US S&T Countries

	I	II	III	IV	V	VI	VII
I. Entry of Firms	1.00						
II. Non-universiy Patenting |	0.49	1.00					
III. Stars Scientists and Engineers Active	0.50	0.20	1.00				
IV. University Articles Knowledge Stock	0.53	0.42	0.81	1.00			
V. High Impact Articles Knowledge Stock	0.57	0.37	0.89	0.91	1.00		
VI. University Patents Knowledge Stock	0.38	0.25	0.60	0.74	0.62	1.00	
VII. Total Employment in Region/Country	-0.04	0.01	-0.06	0.07	-0.06	-0.02	1.00

OTHER ENGINEERING

U.S. Regions

	I	II	III	IV	V	VI	VII	VIII
I. Entry of Firms	1.00							
II. Non-universiy Patenting |	0.39	1.00						
III. Stars Scientists and Engineers Active	0.36	0.40	1.00					
IV. University Articles Knowledge Stock	0.28	0.78	0.58	1.00				
V. High Impact Articles Knowledge Stock	0.28	0.68	0.69	0.91	1.00			
VI. University Patents Knowledge Stock	0.26	0.80	0.41	0.84	0.73	1.00		
VII. Total Employment in Region/Country	0.59	0.62	0.69	0.54	0.53	0.47	1.00	
VIII. Average Wage per Job in Region	0.27	0.35	0.31	0.26	0.24	0.25	0.50	1.00

Top - 25 Sci & Tech. Countries

	I	II	III	IV	V	VI	VII
I. Entry of Firms	1.00						
II. Non-universiy Patenting |	0.50	1.00					
III. Stars Scientists and Engineers Active	0.51	0.84	1.00				
IV. University Articles Knowledge Stock	0.43	0.86	0.93	1.00			
V. High Impact Articles Knowledge Stock	0.49	0.82	0.97	0.96	1.00		
VI. University Patents Knowledge Stock	0.43	0.84	0.89	0.94	0.90	1.00	
VII. Total Employment in Region/Country	0.05	0.11	0.11	0.14	0.11	0.12	1.00

Top - 24 Non -US S&T Countries

	I	II	III	IV	V	VI	VII
I. Entry of Firms	1.00						
II. Non-universiy Patenting |	0.38	1.00					
III. Stars Scientists and Engineers Active	0.40	0.26	1.00				
IV. University Articles Knowledge Stock	0.33	0.48	0.76	1.00			
V. High Impact Articles Knowledge Stock	0.33	0.29	0.81	0.80	1.00		
VI. University Patents Knowledge Stock	0.29	0.35	0.58	0.72	0.44	1.00	
VII. Total Employment in Region/Country	-0.05	0.01	-0.08	0.07	-0.07	0.03	1.00

COMPUTING/INFORMATION TECHNOLOGY

U.S. Regions

	I	II	III	IV	V	VI	VII	VIII
I. Entry of Firms	1.00							
II. Non-universiy Patenting |	0.54	1.00						
III. Stars Scientists and Engineers Active	0.70	0.49	1.00					
IV. University Articles Knowledge Stock	0.51	0.57	0.72	1.00				
V. High Impact Articles Knowledge Stock	0.60	0.63	0.78	0.92	1.00			
VI. University Patents Knowledge Stock	0.49	0.74	0.59	0.83	0.77	1.00		
VII. Total Employment in Region/Country	0.67	0.34	0.81	0.60	0.57	0.48	1.00	
VIII. Average Wage per Job in Region	0.35	0.24	0.36	0.28	0.26	0.25	0.49	1.00

Top - 25 Sci & Tech. Countries

	I	II	III	IV	V	VI	VII
I. Entry of Firms	1.00						
II. Non-universiy Patenting |	0.64	1.00					
III. Stars Scientists and Engineers Active	0.85	0.70	1.00				
IV. University Articles Knowledge Stock	0.77	0.79	0.90	1.00			
V. High Impact Articles Knowledge Stock	0.81	0.71	0.96	0.96	1.00		
VI. University Patents Knowledge Stock	0.69	0.85	0.80	0.90	0.86	1.00	
VII. Total Employment in Region/Country	0.10	0.10	0.12	0.15	0.12	0.10	1.00

Top - 24 Non -US S&T Countries

	I	II	III	IV	V	VI	VII
I. Entry of Firms	1.00						
II. Non-universiy Patenting |	0.45	1.00					
III. Stars Scientists and Engineers Active	0.51	0.06	1.00				
IV. University Articles Knowledge Stock	0.58	0.37	0.57	1.00			
V. High Impact Articles Knowledge Stock	0.51	0.19	0.74	0.87	1.00		
VI. University Patents Knowledge Stock	0.37	0.57	0.26	0.53	0.39	1.00	
VII. Total Employment in Region/Country	-0.03	0.02	-0.08	0.13	-0.01	0.00	1.00

Table B.2. Firm Entry into New Technologies – Firm Entries Detected on Stars' Articles & Patents Excluded
Poisson Regressions – U.S. Functional Economic Regions, 1981-2004

Explanatory Variables	Science and Technology Areas of Firm Entry					
	Bio/Chem/Med	Computing/IT	Nanotechnology	Semiconductors	Other Sciences	Other Engineering
Star Scientists & Engineers Active in Region/ Country in Same S&T Area as Entry	0.0076*** (0.0008)	0.0030 (0.0047)	0.0455*** (0.0140)	0.0048 (0.0059)	0.1700*** (0.0031)	0.0353*** (0.0062)
High Impact Articles Knowledge Stock in Same S&T Area as Entry	-0.0012* (0.0006)	0.0196*** (0.0034)	0.0435* (0.0222)	0.0404*** (0.0055)	0.0037*** (0.0011)	-0.0292*** (0.0069)
University Articles Knowledge Stock in Same S&T Area as Entry	0.0000* (0.0000)	-0.0008*** (0.0001)	-0.0012 (0.0008)	-0.0010*** (0.0001)	-0.0006*** (0.0001)	0.0016*** (0.0004)
University Patents Knowledge Stock in Same S&T Area as Entry	-0.0048*** (0.0009)	-0.0213* (0.0069)	-0.0053 (0.0049)	0.0373*** (0.0095)	0.0049*** (0.0021)	-0.0090** (0.0032)
Total Employment in Region/Country (millions of persons)	0.0978*** (0.0186)	0.1936*** (0.0245)	0.0963*** (0.0232)	0.2399*** (0.0342)	0.1947*** (0.0190)	0.1437*** (0.0170)
Average Wage per Job in Region (thousands of 2000 dollars)	0.1280*** (0.0071)	0.1418*** (0.0068)	0.1995*** (0.0098)	0.1314*** (0.0088)	0.1150*** (0.0083)	0.1210*** (0.0064)
Constant	-1.8924*** (0.1856)	-1.2861*** (0.1734)	-5.1816*** (0.2623)	-3.0134*** (0.2273)	-2.2083*** (0.2223)	-0.9841*** (0.1707)
Dummy = 1 in 2002, else 0	-0.8256*** (0.1109)	-1.1006*** (0.0754)	-0.7353*** (0.1300)	-0.7262 (0.1168)	-0.9360*** (0.1397)	-1.1001*** (0.1124)
Dummy = 1 in 2003, else 0	-1.2731*** (0.1143)	-1.9574*** (0.0953)	-1.4325*** (0.1306)	-0.9287*** (0.1197)	-1.2565*** (0.1212)	-1.7302*** (0.1201)
Dummy = 1 in 2004, else 0	-2.0281*** (0.1362)	-3.3241*** (0.1051)	-2.6212*** (0.1728)	-1.5522*** (0.1378)	-2.2583*** (0.1403)	-3.1067*** (0.1427)
Pseudo R²	0.6148	0.6330	0.5245	0.5248	0.5237	0.5805

Notes: Robust standard errors in parentheses below coefficient estimates. N = 4296. Significance levels: ^ 0.10, * 0.05, ** 0.01, ***0.001
1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Technology articles & patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.
2. Knowledge stocks are computed as a perpetual inventory of the indicated series with 20% depreciation applied to the prior year's stock.

Table B.3. Firm Entry into New Technologies – Firm Entries Detected on Stars' Articles & Patents Excluded
Poisson Regressions – Top-25 Science & Technology Countries, 1981-2004

Explanatory Variables	Science and Technology Areas of Firm Entry					
	Bio/Chem/Med	Computing/IT	Nanotechnology	Semiconductors	Other Sciences	Other Engineering
Star Scientists & Engineers Active in Region/ Country in Same S&T Area as Entry	0.0033*** (0.0001)	-0.0013 (0.0096)	0.0595*** (0.0048)	0.0137* (0.0054)	0.0178*** (0.0037)	0.0246** (0.0082)
High Impact Articles Knowledge Stock in Same S&T Area as Entry	-0.0019*** (0.0001)	-0.0034 (0.0063)	-0.0005 (0.0039)	-0.0033 (0.0027)	-0.0038*** (0.0006)	0.0003 (0.0020)
University Articles Knowledge Stock in Same S&T Area as Entry	0.0000*** (0.0000)	0.0002*** (0.0000)	0.0003*** (0.0000)	0.0000 (0.0000)	0.0002*** (0.0001)	0.0002^ (0.0001)
University Patents Knowledge Stock in Same S&T Area as Entry	-0.0010*** (0.0001)	-0.0097*** (0.0022)	-0.0023*** (0.0004)	-0.0039 (0.0027)	-0.0046*** (0.0005)	-0.0023*** (0.0005)
Total Employment in Region/Country (millions of persons)	-0.0015*** (0.0003)	-0.0013 (0.0002)	0.0000 (0.0004)	-0.0001 (0.0004)	-0.0005 (0.0003)	-0.0004 (0.0003)
Constant	2.7651*** (0.0477)	3.2904*** (0.0706)	1.5902*** (0.1008)	2.1965*** (0.1163)	1.9296*** (0.0998)	3.3105*** (0.0916)
Dummy = 1 in 2002, else 0	-0.2534^ (0.1078)	-0.8858*** (0.1560)	-0.6278*** (0.0989)	0.3351 (0.1803)	-0.2906^ (0.1719)	-0.4265* (0.2057)
Dummy = 1 in 2003, else 0	-0.4536** (0.1388)	-1.1131^ (0.4314)	-1.3859*** (0.1627)	0.4131^ (0.2097)	-0.9210*** (0.2367)	-0.8961*** (0.1905)
Dummy = 1 in 2004, else 0	-2.2415*** (0.5037)	-2.31o2** (0.4303)	-1.8297*** (0.4601)	-0.1666 (0.2080)	-2.4620*** (0.4921)	-1.7683*** (0.1969)
Pseudo R²	0.8801	0.6021	0.7612	0.7705	0.8518	0.8562

Notes: Robust standard errors in parentheses below coefficient estimates. N = 600. Significance levels: ^ 0.10, * 0.05, ** 0.01, ***0.001
1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Technology articles & patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.
2. Knowledge stocks are computed as a perpetual inventory of the indicated series with 20% depreciation applied to the prior year's stock.

Table B.4. Firm Entry into New Technologies – Firm Entries Detected on Stars' Articles & Patents Excluded
Poisson Regressions – Top-24 Non-U.S. Science & Technology Countries, 1981-2004

Explanatory Variables	Science and Technology Areas of Firm Entry					
	Bio/Chem/Med	Computing/IT	Nanotechnology	Semiconductors	Other Sciences	Other Engineering
Star Scientists & Engineers Active in Region/ Country in Same S&T Area as Entry	0.0093*** (0.0014)	0.0322*** (0.0076)	0.0419^ (0.0226)	0.0044 (0.0099)	-0.0096 (0.0140)	0.0717*** (0.0187)
High Impact Articles Knowledge Stock in Same S&T Area as Entry	-0.0014* (0.0006)	-0.0079** (0.0038)	0.0306*** (0.0089)	0.0176*** (0.0027)	0.0042 (0.0026)	0.0028 (0.0073)
University Articles Knowledge Stock in Same S&T Area as Entry	0.0000*** (0.0000)	0.0003*** (0.0000)	-0.0000 (0.0001)	0.0000* (0.0000)	0.0002*** (0.0001)	0.0001 (0.0001)
University Patents Knowledge Stock in Same S&T Area as Entry	-0.0003 (0.0009)	-0.0201 (0.0150)	0.0136*** (0.0021)	-0.0070 (0.0078)	-0.0134^ (0.0078)	0.0068** (0.0027)
Total Employment in Region/Country (millions of persons)	-0.0009*** (0.0002)	-0.0011*** (0.0002)	-0.0003 (0.0003)	-0.0004 (0.0003)	-0.0007** (0.0003)	-0.0003 (0.0003)
Constant	2.3185*** (0.0424)	2.8089*** (0.0637)	1.1037*** (0.0610)	1.3611*** (0.0571)	1.5685*** (0.0611)	2.8509*** (0.0565)
Dummy = 1 in 2002, else 0	-0.1762 (0.1568)	-1.1293*** (0.1578)	-0.8827*** (0.2448)	0.1954^ (0.1014)	-0.0859 (0.1509)	-0.7907** (0.2617)
Dummy = 1 in 2003, else 0	-0.2672 (0.1632)	-1.3410*** (0.2514)	-1.5007*** (0.2535)	-0.0524 (0.1448)	-0.5255** (0.1699)	-1.1793*** (0.2531)
Dummy = 1 in 2004, else 0	-0.8054*** (0.1872)	-2.7784*** (0.2577)	-1.7391*** (0.3063)	-0.1210 (0.1124)	-0.9535*** (0.2176)	-2.0366*** (0.2503)
Pseudo R²	0.5875	0.5378	0.4379	0.5013	0.4424	0.4773

Notes: Robust standard errors in parentheses below coefficient estimates. N =576 . Significance levels: ^ 0.10, * 0.05, ** 0.01, ***0.001
1. The science and engineering areas are Biology/Chemistry/Medicine; Computing & Information Technology; Semiconductors, Integrated Circuits & Superconductors; Nanoscale Science & Technology; Other Sciences; and Other Engineering. Nanoscale Science & Technology articles & patents as defined for NanoBank.org are removed from the other five areas into which they would otherwise be classified.
2. Knowledge stocks are computed as a perpetual inventory of the indicated series with 20% depreciation applied to the prior year's stock.

Figure 1. Star Scientists and Engineers Increase the Probability of Firm Entry into New Technologies
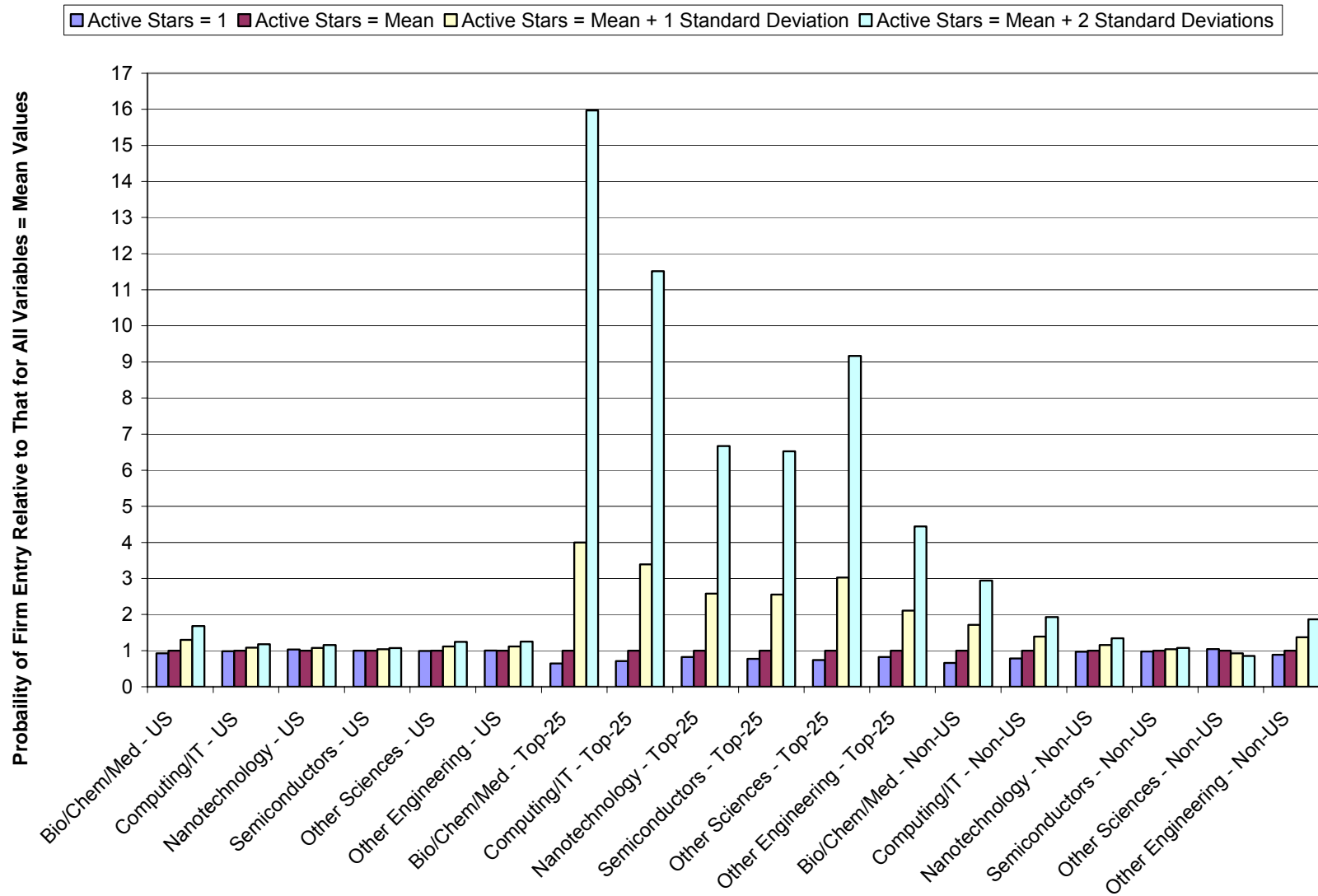Relative Probabilities with Different Numbers of Active Stars, All Other Variables = Mean Values

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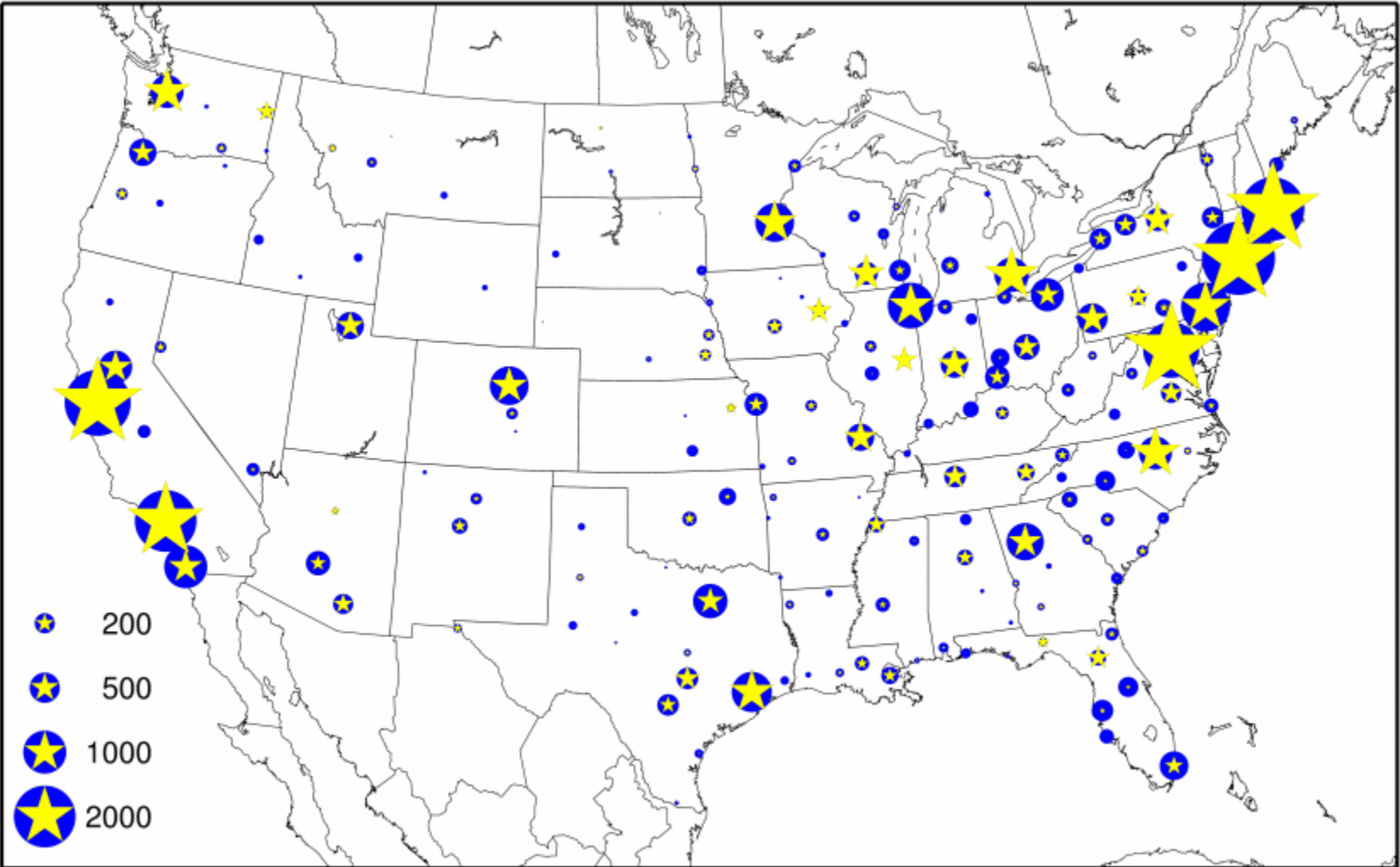Figure 2. Biology/Chemistry/Medicine Star Scientists & Firm Entry, U.S. Regions, 1981-2004

- 200
- 500
- 1000
- 2000

Figure 3. Nanoscale Science and Technology Star Scientists & Firm Entry, U.S. Regions, 1981-2004

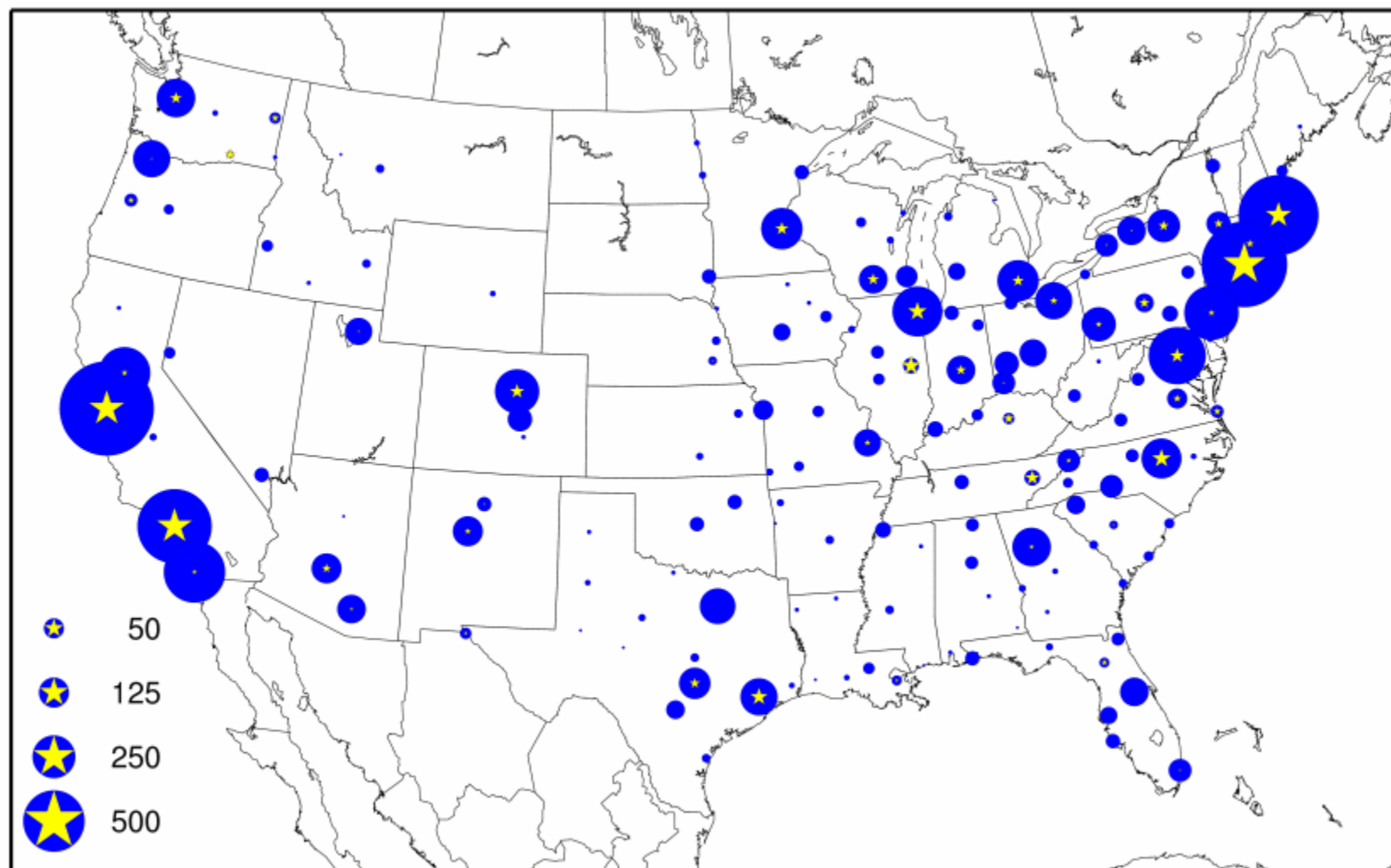|	
☆	50
⭐	125
⭐	250
⭐	500

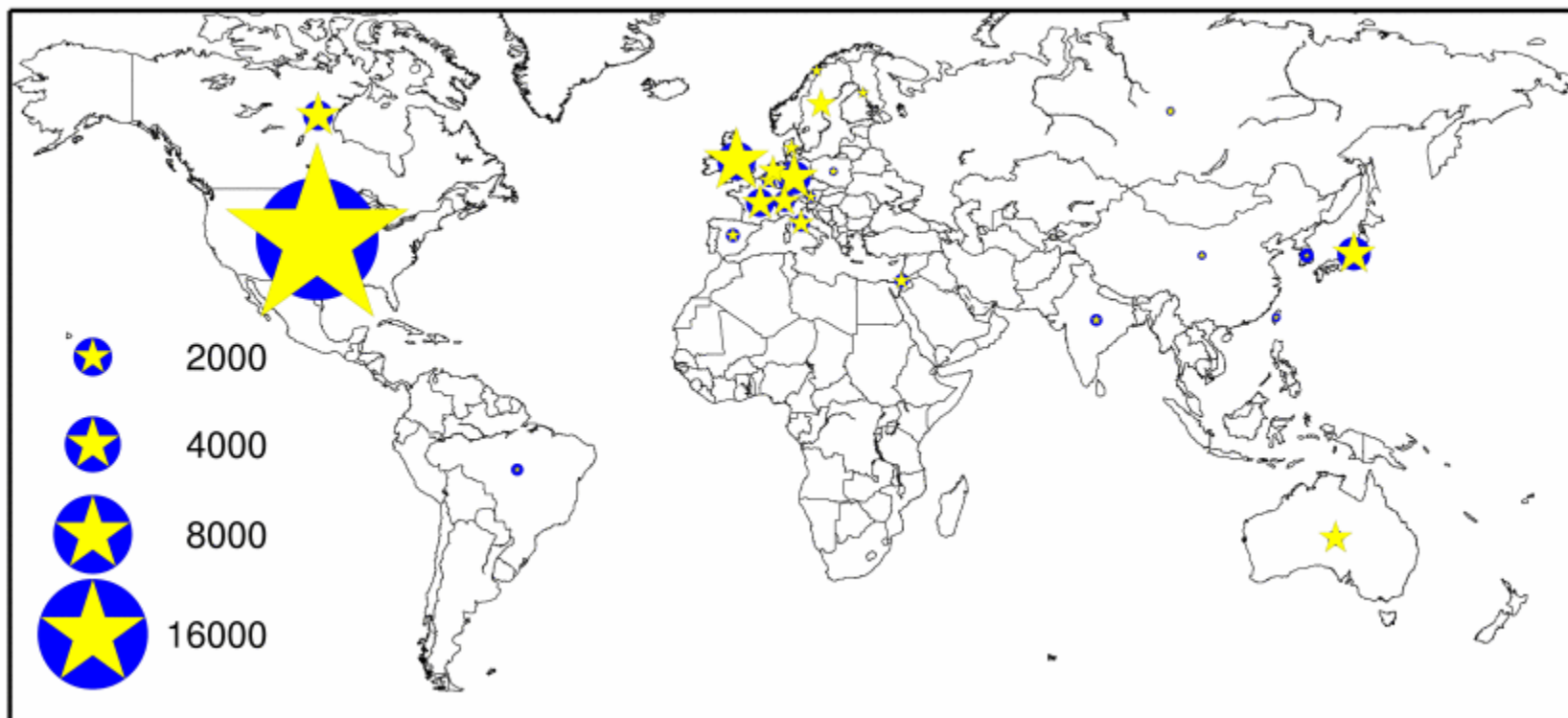Figure 4. Biology/Chemistry/Medicine Star Scientists & Firm Entry, 25 Countries, 1981-2004

Figure 5. Nanoscale Science and Technology Star Scientists & Firm Entry, 25 Countries, 1981-2004