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Abstract

This study investigates widening access to the Internet and other advancements in IT across institutions of higher education and how these advances have affected the publishing productivity of academic life scientists. What distinguishes this study is that institutional IT access is measured across a wide range of institutions and multiple IT indicators are considered: 1) the adoption of BITNET; 2) the registration of domain names (DNS); 3) the availability of the electronic journal database, JSTOR; and 4) the availability of electronic library resources. Data on life scientists are drawn from the 1983, 1995, 2001, and 2003 Survey of Doctorate Recipients. Universities and colleges are classified into several tiers, depending upon research intensity. Three hypotheses are tested: 1) IT enhances the careers of faculty, independent of tier; 2) IT improves the careers of faculty at lower-tiered relative to higher-tiered institutions; and 3) within tier, the IT revolution increases women's publication rates relative to their male counterparts. The study finds that the diffusion of IT in higher education follows the standard S-curve, with higher-tiered institutions innovating more quickly. Results regarding the impact of IT on the publishing productivity of life scientists provide some support for the first two hypotheses but no support for the third hypothesis.

Key Words: Diffusion, Technology, Life Sciences, Professional Labor Markets, Gender

JEL classifications: O33, J44, J16

Introduction

This paper investigates widening access to the Internet and other advances in information technology (IT) across institutions of higher education and how these technologies have impacted the publishing productivity of academic life scientists. It builds upon the work of others, including Cole & Zuckerman (1984), Zuckerman (1991), Long (2001), Hamermesh & Oster (2002), Xie & Shauman (2003), Butler, Butler & Rich (2008), Kim, Morse & Zingales (forthcoming), and Agrawal & Goldfarb (2008). What distinguishes this study from others is that it looks at the emergence of these technologies across a wide range of institutions and is the first to use multiple indicators of IT. An institution's "connectivity" is measured using two indicators. The first of these, the adoption of BITNET, captures a technology that was a major forerunner to the modern day Internet.[1] Introduced in 1981, BITNET was superceded by the modern day Internet by the mid-1990s. In order to facilitate communication on the Internet, institutions adopted domain names which they registered on the Domain Name System (DNS) beginning in 1985; these registration dates provide our second IT indicator of connectivity. In addition, we look at two indicators of the availability of research-related IT: institutional access to JSTOR and off-campus access to electronic institutional library resources.

Three hypotheses are examined. The first, termed the IT-enhancing hypothesis, is that IT, by creating a virtual scholarly community and by providing easier access to data and the research of others, enhances the publishing productivity of scientists,

[1]Although the IT revolution can be dated to the creation of ARPANET by the Department of Defense in 1969, restricted access to ARPANET led others to develop their own networks. (National Science Foundation 2009). While BITNET was not the only one among these, nor the first, it became a leader during this period as discussed in the text.

regardless of their location. The second, termed the "sectoral hypothesis" is that the IT revolution improves the career opportunities of faculty at secondary (lower-tiered) institutions relative to faculty at primary (higher-tiered) institutions. We argue that this differential effect is due to the fewer in-house colleagues and resources that individuals working in the secondary sector had prior to the introduction of IT. The third hypothesis, termed the "opportunity-enhancing effect," is that women benefit more than men from opportunities made available through the revolution in information technologies. The hypothesis is based on the fact that family issues typically constrain the mobility of women more than the mobility of men.[2] To quote Fountain (2000, p. 47), "the capacity of information technologies to enable more flexible, family-friendly work arrangements may assist women to combine work and family in ways that offer new possibilities for professional career …."

We note that the narrowing in the publishing gap between men and women observed by Xie & Shuman (2003), among others, is consistent with the second and third hypotheses. To wit, women, who are disproportionately represented at second tier institutions, have likely benefited from both the "sectoral effect" and the "opportunity-enhancing effect."

To explore the impact of the IT revolution on publishing productivity, we append institutional-level data collected on IT indicators to individual-level data on full-time faculty in the life sciences at four-year colleges, medical schools and research institutions. The individual-level data come from the 1983, 1995, 2001, and 2003 *Survey*

[2] Polachek & Horvath (1977) and Mincer (1978). For a review of recent studies and discussion, see Blau, Ferber & Winkler (2006).

of Doctorate Recipients (SDR).[3] We focus on the life sciences because it is a large discipline and has the largest proportion of women in all of the natural sciences. Further, considerable interest surrounds career paths in the life sciences (National Research Council 1998, National Research Council 2005, and Teitelbaum 2008). Productivity is measured as the count of published articles. Each institution is assigned to a tier based on the quality of the institution's program in the life sciences.

Literature Review

A burgeoning literature is shedding light on the role of information technologies in academia. It is no longer a matter of "location, location, location." Instead, the long-held advantage of holding a position at a top academic institution is diminishing. Evidence comes from the work of Agrawal & Goldfarb (2008), who find that medium-ranked research universities, but not the top research universities, benefited the most from the adoption of BITNET[4] during the 1980s in terms of increased publications in the field of electrical engineering. Another manifestation of the transformation in academia is the increase in the number of co-authored papers by individuals at different institutions (and in different countries), as well as in the number of co-authors per paper. For the top 110 universities in the United States, for example, Adams et al. (2005) report that the average number of authors per paper in the sciences grew by 53.4 %, rising from 2.77 to 4.24, over the period 1981-1999. The authors also identify a growing mean distance between coauthors at these top institutions, from 77.7 miles in 1981 to 159.4 miles in 1999. Both patterns are consistent with benefits relating to the diffusion of IT.

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[3] All authors have a restricted license to use the SDR data.
[4] This network predates what we now call the Internet since it did not use the TCP/IP standard.

In related work, Hamermesh & Oster (2002) compare publishing activity in three economics journals over the period 1970-1979 with publishing activity in the same journals over the period 1992-1996. The authors find that almost 20% of authors of jointly-produced articles are located at distant locations in the later period compared with 5% in the earlier period. They attribute these differences to new technologies such as e-mail that lowered communication costs between the two time periods. Kim et al. (forthcoming) examine co-authorship patterns over the period 1970-2001 in the fields of economics and finance. Like other authors, they identify an increase in co-authorship overall, but especially at lesser-ranked institutions, consistent with a role for IT. Finally, Butler et al. (2008) examine collaboration across universities in the fields of economics and political science using publication data from three top journals in each field. In their paper, they measure the availability of IT based on a review of NBER papers published during the 1990s. They find that prior to January 1997, an e-mail address was never included in the address; since January 1999, almost all papers had an e-mail address.[5] Using this as an indicator of IT access, they find that IT increases collaboration and that the effect is stronger at lower-ranked universities. One further contribution of Butler et al. (2008) is that they explicitly examine gender differences in the effect of IT. Notably, however, they find no significant differences.

Our research expands on these studies in several directions. For one, we examine the dissemination of technology across all four-year colleges, universities and research institutions, thereby using a much broader set of institutions than previous studies have used. Second, in contrast to earlier studies, we measure IT by the availability of multiple

[5]Part of the explanation for the limited use of an e-mail address prior to 1997 may be that the NBER only explicitly required an address after January 1997.

technologies instead of only one technology. Finally, and building upon the research conducted by Butler et al. (2008), we examine the impact of IT on gender differences in publishing in the present study of academic life scientists.[6]

Our study is not without limitations. Given the design of the SDR, productivity is measured using publication counts, but the data do not provide information on co-authorship nor do they permit controlling for journal quality. Furthermore, the definition of a publication is not consistent over all survey years, nor is the number of years for which publication data are collected (two vs. five years). Nonetheless, this study provides an important step in examining the impact that the diffusion of information technology has had on publishing productivity in academia.

IT Data

The IT indicators examined here are drawn from four sources: 1) data on the adoption of BITNET; 2) data on the adoption of domain names (DNS); 3) data on the adoption of JSTOR; and 4) data on the availability of electronic library services. The first of these indicators reflect "connectivity;" the latter two reflect access to research-related IT. Data for these four indicators were collected for a set of 1,348 four-year colleges, universities and medical schools in the United States that had been in existence since 1980.[7]

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[6]In preliminary work, we also studied the social sciences.

[7]The universe of institutions was initially formed by a careful review of years of institutional data available in *IPEDS*. For further details see Levin et al. (2009). There were also a number of additional institutions in the SDR sample that were not in the IPEDS dataset because of how the institutional database was constructed. Data on the IT measures for these institutions were also collected so that they could be included in the subsequent individual-level analysis of publishing activity.

The BITNET data capture the adoption of IT during the early years of our study (1980s). Conceptualized by the Vice Chancellor of University Systems at the City University of New York (CUNY), BITNET's first adopters were CUNY and Yale in May 1981 (*BITNET history*). Complete data for the period of BITNET adoptions, 1981-1990, have been compiled from the *Atlas of Cyberspaces*.[8] In order to extend our analysis into later periods, we also include another indicator of IT access: namely, an institution's adoption of the domain name system (DNS) invented in 1984 (Griffiths, 2002). These data indicate when universities formally registered their domain names on the Internet (*ALLWHOIS* registry site, on-line).[9] The adoption of a domain name is an important measure of access since a domain name facilitates communications by substituting a simple name for the multi-digit IP address that was formerly needed.

The first of the IT indicators that reflect electronic access to research materials is an institution's adoption of JSTOR. JSTOR provides a university with access to and usage of one or more collections of research articles (Schonfeld 2003). These data were provided to us through a research agreement with JSTOR and contain information on institutions participating in JSTOR from its inception in late 1996 through February 2007.[10]

A second indicator of research-related access to IT is the availability of electronic library services. These data have been collected by the National Center for Education

[8]After this date, data were no longer systematically collected because of the availability of competing and superior technology, i.e., the modern-day Internet.
[9]In cases where the university had more than one server registered, we examined the dates of all named servers and recorded the earliest date. Because branch campuses may have relied on a system-wide server before obtaining their own domain names, we collected both the earliest date of the domain name registered for the system, along with the earliest date that the branch campus registered its own domain name, and used the former in the study.
[10] JSTOR became officially available in January 1997, but some adoptions occurred in late 1996.

Statistics (NCES) since 1996 as part of its biennial surveys of academic libraries and indicate the ease of faculty access to IT-related services, not just the access of faculty at each institution to the Internet. For 1996, 1998 and 2000, the survey asked, among other questions, about the availability of electronic access to library reference services from off campus.[11]

Figures 1-7 depict the diffusion of IT across the set of 1,348 institutions for each of these four indicators, treating all institutions as a group as well as stratifying by institutional grouping as defined by the 1994 Carnegie codes (Carnegie Foundation for the Advancement of Teaching 1994). The first grouping refers to Research and Medical Institutions. A second grouping refers to Masters-Level Institutions, and a third grouping refers to Liberal Arts Institutions. For BITNET, DNS, and to a lesser extent, JSTOR, the data exhibit the usual S-curve associated with diffusion patterns (for example, Stoneman 2002; Geroski 2000; and Rogers 2003): adoption first rises at an increasing rate and then levels off.

In the case of BITNET, as shown in Figure 1, 31% of the 1,348 institutions studied had adopted the technology by October 1990, the last date for which complete data were collected. Figure 2 goes on to show that Research and Medical institutions were much more likely to be early adopters of BITNET and adopted it at a much faster rate than other institutions. Indeed, by October 1990, 81 % of Research and Medical institutions had adopted BITNET, compared to just 25 % of Masters-level and 13 % of Liberal Arts institutions. Further diffusion would likely have occurred if this technology had not become outdated.

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[11]In surveys after 2000, questions about e-mail reference services and library internet services are combined. See, http://nces.ed.gov/surveys/libraries/.

Figures 3 and 4 depict the diffusion pattern of domain names. This technology, first adopted by institutions in early 1985, was adopted by all institutions by June 2006. Research and Medical institutions were more likely to be early adopters and adopted at a much faster rate.

Figures 5 and 6 portray diffusion patterns for JSTOR. By February 2007, 74% of all institutions had subscribed to at least one JSTOR collection. Adoption rates varied by tier; 64% of Liberal Arts institutions had adopted JSTOR by February 2007 while 85% of Research and Medical institutions had done so by the same date. Interestingly, Liberal Arts institutions initially adopted JSTOR at a faster rate than Masters-level institutions, a different pattern than seen for either BITNET or DNS.

Finally, Figure 7 examines the availability of electronic library resources from off campus. By 2000, virtually all Research and Medical institutions and nearly all Masters-level institutions had off-campus electronic library access , while only 83% of Liberal Arts schools did.

Individual-Level Analysis: SDR Data

We examine the impact of IT on the publishing rates of academic life scientists by matching their institutional affiliation to the IT indicators described above. Individual-level data are drawn from the SDR surveys for 1983, 1995, 2001, and 2003.[12] The 1983 SDR, which counts publications for the period 1981-1982, provides information on publishing productivity before major changes in IT occurred. The 1995 SDR counts publications for the five previous years (1990-1995) and thus provides information on publishing productivity for the period when BITNET was still in use and the Internet was

[12]While the SDR was conducted for the sciences in other years, information on publication counts, a key measure here, was not collected.

in its formative stage. Indeed, the Web did not become available until 1993, and in the early years of the Internet the lack of good browsers made it difficult to conduct searches and e-mail was not yet in wide use.[13] Finally, data from the 2001 SDR (publication counts for 1995-2001) and 2003 SDR (publication counts for 1998-2003) provide information on publishing productivity during a period when access to the Internet by institutions of higher education was almost universal, as we have seen from Figures 3-7. In the later years, expansion of the Web was facilitated by the introduction of web browsers such as Mosaic (1993), Netscape (1994) and Internet Explorer (1995).

The sample consists of full-time faculty in the life sciences holding doctorate degrees employed as assistant, associate, or full professors in four-year colleges and universities, and medical institutions.[14] These faculty members may be in one of a number of situations: they may hold a tenured or tenure-track position, may hold a non-tenure track position, and/or may hold an appointment at an institution which does not have a tenure system. The sample excludes post docs as well as those indicating zero years at the present institution. Research and staff scientists who do not hold academic rank are also excluded.

The 1983, 1995, 2001, and 2003 SDR surveys includes information on the individual's year of Ph.D., marital status, race, citizenship, tenure status, and publication information. The surveys from 1995 on also include information on age, children, years

[13]The use of e-mail took off around 1994-1995, fueled, in part, by the explosion in lower-cost, more powerful, personal computers and growing access to the Web with "free" e-mail accounts through providers such as Yahoo.

[14]The sample excludes individuals at two-year institutions; schools of theology; other separate health-related schools (except the Mayo Graduate School); engineering and technology; business; art, music, and design; law; other specialized institutions; tribal schools, and those with missing information on type of school. These schools correspond to the 1994 Carnegie designation of 40, 51, 53, 54, 55, 56, 57, 58, 59, 60, and M, respectively.

at present job, and whether the individual changed employer between the survey date and two years prior. The data sets also include information about the individual's institution: whether it is public or private, whether or not it is a medical school and the institution's 1994 Carnegie code.

The publication measure available in the SDR is the number of journal articles, the major method for disseminating scientific work in most fields. As indicated earlier, the specific publication information available differs by survey. The 1983 SDR has publication information for the period April 1981 – April 1983 (2 years). In this survey, respondents were asked to indicate "the number of publications you have authored or co-authored in the following categories during the past two years," with "journal articles" being one of the categories that the respondent could check. Unfortunately, the question fails to restrict the answer to "refereed" publications. It is also vague as to whether the respondent is meant to include articles that have been accepted but are yet to be published. In contrast, in 1995 and later years, the survey question is worded more precisely: "Since… how many articles, (co)authored by you, have been accepted for publication in a refereed professional journal?" For 1995, the relevant publication period is from April 1990 – April 1995 (5 years); for 2001, the period is from April 1995-April 2001 (6 years); and for 2003, the period is from October 1998-October 2003 (5 years).

In the analysis, we examine the number of publications that the scientist reported, adjusting for "exposure," the period of time covered by the survey question (see discussion of Poisson estimation strategy to follow). We then relate the number of publications to the availability of IT immediately preceding the period of exposure. By way of example, if in 1995 an individual reported ten publications for a five year period, the individual's publication count is ten, the period of exposure is five and the IT variable takes on a value of 1 if the institution had access to IT in 1989 or earlier. The average annual publication flow is two.[15]

In approximately nine percent of the cases, the scientist changed universities during the survey period. This complicates the analysis since we are interested in relating productivity to the IT regime available at the institution where the research was performed. To correct for this, we adjust publication counts, assuming a uniform distribution of output. We also adjust the measure of exposure to reflect time at the current institution.[16]

The individual-level analysis includes controls for gender, citizenship, and race. Race is measured by a set of three dummy variables: underrepresented minorities, Asians, and whites, where whites are the omitted group. To account for differences in "career stage"[17] and tenure status, individuals are classified into one of four groups: early-career stage is defined as on tenure track, but not yet tenured; mid-career is defined as tenured with less than 20 years experience at the current or past institutions; later-career is defined as tenured with 20 or more years of total experience. The fourth category (the omitted group in the regressions) includes those who are in non-tenure track positions or

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[15] An earlier version of this paper used the average annual publication flow as the dependent variable.

[16] By way of example, if an individual worked at the current institution for three of the five years, the adjusted count is three-fifths of the total five-year count; the period of exposure is three. This adjustment method over attributes publication counts to the current institution if the current institution's research environment is weaker than the previous institution's; it under attributes publication counts, if the current institution is stronger. Sensitivity testing, discussed later, suggests that the results change little if movers are excluded from the sample. Our concerns are further reduced because the lag between paper submission and acceptance is approximately a year in the life sciences (Ellison, 2002a).

[17]Work by Stephan and Levin (2001) emphasizes the importance of career stage and not age *per se* in the life-cycle of the academic career.

at an institution without a tenure system. Family responsibilities are measured by an indicator variable where never-married takes on the value of 1; 0 otherwise. In the analyses conducted using the 1995, 2001, and 2003 SDR surveys, which also include information on the presence and age of children, a child indicator is also included that takes on the value of 1 if the individual has at least one child under age 6; 0 otherwise. Further, given evidence on the differential impact of children on women's and men's labor market outcomes (Xie & Shauman 2003), the child indicator is also interacted with gender. The models also control for whether the institution is private or public as well as the research tier of the institution.

Specifically, we develop a four-tier system, ranking academic institutions according to the strength of their research environments in the life sciences. This classification system is more finely grained than the scheme used to differentiate diffusion patterns in Figures 1-7, and that used in previous individual-level studies (such as Ginther & Hayes 2003; Ginther & Kahn 2006). While the Carnegie classification system distinguishes between the types of institutions where an individual works, the classification is neither program nor department specific. For the present analysis, however, what really matters is the quality of the life sciences department or program with which the individual life scientist is associated, not the overall ranking of the university. Thus, we supplement the Carnegie categories with data from the National Research Council on the ratings of doctoral programs in various disciplines and use these to identify top research environments in the life sciences. We match the 1995, 2001, and 2003 SDR data with the 1993 NRC rankings (National Research Council 1995) and the

1983 SDR with the 1982 NRC rankings (Jones, Lindzey & Coggeshall 1982).[18] We identify top medical schools, which were not ranked by the NRC in either report, by the amount of extramural research funding they received from the National Institutes of Health (NIH).[19]

The four tiers used in the individual-analysis are defined as follows:

Tier 1: Doctoral-granting programs rated Distinguished or Strong by the NRC and/or medical schools that received substantial funding from NIH.

Tier 2: Doctoral programs (rated Good, Adequate, Marginal and Not sufficient for graduate education by the NRC) and other research-oriented institutions. In terms of the Carnegie classification, this tier includes the code of 11, 12, 13, 14 (Research I and II, Doctoral I and II), Medical Schools (52) not already included in Tier 1.

Tier 3: Master's (comprehensive) universities (Carnegie Code 21, 22) and Liberal Arts I (31).

Tier 4: Liberal Arts II (Carnegie Code 32).

In this categorization, the set of Research and Medical Institutions identified earlier in the institutional analysis (Figures 1-7) are now spit between Tiers 1 and 2 , with Tier 1 capturing the most research-oriented of these programs. A further distinction made here is between Liberal Arts schools. Those that are more likely to emphasize

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[18]In 1993, doctoral programs were ranked by the NRC as Distinguished, Strong, Good, Adequate, Marginal, or Not Sufficient for Doctoral Education and were assigned scores of 1 to 5, with "Distingushed" having a score of 1. Institutions with programs ranked lower than 3 (Distinguished or Strong) were placed in Tier 1. In cases in which institutions have multiple doctoral-granting programs in a broad disciplinary area, scores were averaged across programs as was done by Adams et al. (2005). Other institutions that had programs ranked lower by the NRC (scores 3 or higher) were placed in Tier 2. In 1982, fewer programs/disciplines were ranked by NRC than in 1993, but otherwise the same approach was followed. In some instances, an NRC score was available for 1982 or 1993, but not both. In such cases, the score for the available year was used for the missing year.

[19]Information was obtained from http://grants.nih.gov/grants/award/rank/medttlnod.htm. Medical schools are assigned to Tier 1 if they are among the 50 institutions receiving the largest amount of extramural research awards from NIH. The awards ranking for 2001 is matched with the 2003 SDR; 1998 with the 2001 SDR; 1993 with the 1995 SDR; and 1981 with the 1983 SDR. As would be expected, these schools overlap considerably with those institutions identified by the NRC as having Distinguished or Strong programs.

research are included in Tier 3; those that focus almost exclusively on teaching make up Tier 4.

Table 1 shows the IT indicators used in the individual-level analysis. Seven period-specific variables are developed. For the 1983 SDR (publication data from 1981-1983), we create an indicator of whether the institution had adopted BITNET by December 1982.[20] For the 1995 SDR (publication data from 1990-1995), we create an indicator of whether the institution had registered a domain name prior to 1989.

For 2001 and 2003 SDR, in addition to whether the institution had adopted a domain name, we also include indicators of electronic access to scholarly research materials. This means, in the case of the 2001 SDR (publication data from 1995-2001), that we include two IT-related measures: 1) an indicator of whether the institution had a domain name registered prior to 1994; and 2) an indicator of whether electronic library reference services were available to faculty located off campus by 1996. Finally, for the 2003 SDR (publication data from 1998-2001), we have three IT-related measures: 1) an indicator of whether the institution had a domain name registered prior to 1997; 2) and indicator of whether electronic library reference services were available to faculty located off campus by 1998; and 3) an indicator of whether an institution had access to one or more collections of JSTOR prior to October 1997.

Methodology

Several models of publication counts are estimated using Poisson estimation to investigate the hypotheses set forth earlier. The method chosen reflects the nature of the data and its distribution: a notable fraction of individuals have no publications, as

[20]For this period only, the criterion that IT must be available for at least one year prior to the publication count is relaxed, since BITNET did not begin until 1981.

indicated in Table 2, and the distribution of publication counts closely matches a Poisson distribution. The specific Poisson estimation procedure used takes into account several features of the data: the differing periods of "exposure" during which researchers produced their publications, the overdispersion of the count data, and the fact that, in some cases, multiple individuals are located at the same institution.[21] First, to test whether IT (regardless of our indicator measure) "enhances" research productivity, we examine the impact of IT on publishing productivity using data on life scientists located in all tiers as well as stratified by tier. To test the "sectoral hypothesis," we make use of results from the productivity regressions stratified by tier. Specifically, we difference the coefficients on IT from the regressions estimated separately by tier to obtain an estimate of IT's differential impact.[22] Finally, to examine the "opportunity-enhancing" hypothesis as to whether IT enhances women's productivity relative to men's, we estimate regressions of research productivity, stratified by tier, which include a measure of IT and an interaction term between Female and IT.

Models are estimated for each SDR survey year, rather than pooling data over survey years, for two reasons. First, different indicators of IT are relevant to different periods. Second, many factors affecting productivity have changed over time, including

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[21] See discussions in Cameron & Trivedi (2008, pp. 560-561) and Wooldridge (2002, pp. 645-656). Specifically, the estimated results presented here were performed using STATA. We employed a quasi-maximum likelihood approach which maximizes the Poisson MLE and uses robust standard errors clustered around institutions. We also invoked the offset option to capture differing periods of exposure for individual researchers. In earlier work, we estimated models of average annual publication flows (publication counts divided by exposure) using ordinary least squares. Notably, signs and statistical significance of the IT variables are quite similar in both specifications, though Poisson is the preferred method given the count nature of the data.

[22] An equivalent method of obtaining this "differential" impact is to estimate a regression of research productivity over two tiers, where tier is interacted with each covariate including IT. In this latter specification, the coefficient on IT*Tier directly provides the "differential" effect. The method used here was chosen for expository purposes.

supply side factors such as the proliferation of journals, and demand side factors such as tenure/promotion requirements regarding published research. Looking within year effectively controls for these period effects.

Findings

Table 2 provides statistics for the sample of life scientists for the four SDR survey years. The substantial decline in sample size between 1983 and the later years largely reflects a reduction in the SDR survey size, not a marked changed in response rates. Samples sizes are as follows: 1,614 individuals (located at 526 institutions) for the 2003 SDR, 1,834 individuals (located at 530 institutions) for the 2001 SDR, 2,856 individuals (located at 620 institutions) for the 1995 SDR, and 4,447 individuals (located at 663 institutions) for the 1983 SDR.

Sample characteristics are quite similar for the 1995, 2001 and 2003 samples. But, as would be expected, there have been notable changes since 1983. For example, from 1983 to 2003, the percentage female increased from 14% to 26%, the percentage of underrepresented minorities rose from 3% to 7%, and the percentage of non-citizens rose from 4% to 7%.[23]

The average respondent had around 18 years of experience since receiving his/her Ph.D. in the 1995, 2001 and 2003 surveys, but the figure was somewhat lower, at 15 years, in the 1983 survey. Average years on the present job was 16 in 1995, but was closer to 13 years in the 2001 and 2003 survey years (no such data was provided in 1983). The distribution of life scientists by career stage changed considerably between 1983 and 1995 but thereafter remained fairly stable with the exception that the percent of

[23]The SDR sampling frame is drawn from individuals who received their Ph.D. in the U.S. Thus, it does not capture immigrant scientists trained outside the U.S.

individuals in non-tenure track positions grew from 14% to 18%, reflecting the recent trend toward more "non-regular faculty" appointments (Schuster & Finkelstein, 2006). We focus our comparisons of publishing productivity on the top three tiers, excluding individuals working at primarily teaching institutions.[24] For each SDR survey year, around 37-39% of individuals are located in a Tier 1 institution, 40%-43% in a Tier 2 institution, and 16%-18% in a Tier 3 institution.

Table 3 provides data on the average annual publication flow by tier, year, and gender. The table shows that for all years and tiers, men's publishing productivity exceeded (or matched) women's productivity. For instance, in 2003, the publication flow for men and women in Tier 1 was 2.97 and 2.67, as compared to rates of .96 and .86 in Tier 3. The table also shows a much higher publication flow for 1983 as compared with the other years. The 1983 figures are likely higher because this survey did not restrict the count of publications to those that are refereed, as was done in subsequent surveys.

Table 4 shows the percentage of individuals in the life sciences by tier and the availability of IT for various years of the SDR. Just as in Figures 1-7, higher ranked institutions are the ones where IT was more readily available in virtually all instances.

Tables 5 - 9 provide results from the Poisson estimations of publication counts (adjusted for exposure) on IT and the individual and institutional-level covariates discussed earlier.[25] Model 1 of Table 5 provides regression results for all life scientists without controlling for tier, while Model 2 controls for tier.[26] Several comments are in

[24]Comparisons regarding Tier 4 are also limited because of its very small size, representing just 4%-5% of the sample.
[25]Coefficient estimates of covariates for some selected models are shown in Appendix A. They are not displayed in Tables 5-9 for purposes of brevity.
[26]With the exception of Model 1 of Table 5, Tier 4 is excluded from the publishing productivity analysis due to small sample size.

order before discussing the IT-specific results. First, and consistent with Tables 2 and 3, in Model 2 of Table 5 publication rates are significantly lower in Tiers 2 and 3 relative to Tier 1, even after controlling for other factors, including IT availability. Counts are also lower for women. As shown in Models 1 and 2 of Table 5, the gender difference is statistically significant for all models and periods estimated. These models, estimated over all tiers, nonetheless mask notable differences regarding the impact of gender by tier. As Table 6 shows, for Tier 2, the gender difference in publishing is statistically significant for all models and periods estimated. For Tiers 1 and 3, gender is statistically significant only in the earlier years.

Tables 5 and 6 provide estimates of the relationship between publishing productivity and period-specific measures of IT to test the "IT-enhancing" hypothesis, holding gender and other personal and institutional characteristics constant. Model 1 of Table 5 shows that, when tier is omitted, both types of IT, IT-connectivity (as reflected by BITNET and DNS) and research-related IT (as reflected by access to electronic library resources and JSTOR), generally have a statistically significant impact on publishing productivity, providing support for the IT-enhancing hypothesis. The coefficient on IT, however, likely overestimates IT's "pure" effect because the adoption of IT is related to other factors that contribute to research productivity that vary by tier. To capture these, we re-estimate the equation, controlling for tier, thereby identifying any effects of IT separate from tier. As Model 2 shows, once tier is included, IT is no longer statistically significant except in the case Electronic Library Access in 2003. These results, along with an examination of pairwise-correlations of IT and tier, suggest the presence of substantial multicollinearity. Thus, it is particularly instructive to look at the impact of IT on publishing productivity within tier, as shown in Table 6.

The results in Table 6 provide some support for the "IT-enhancing" hypothesis. Within Tier 1, the adoption of domain names (DNS) has a statistically significant effect in the 2001 regression and Electronic Library Access has a significant effect in the 2003 model.[27] Within Tier 3, the availability of BITNET has a statistically significant impact in 1983 and Electronic Library Access has a statistically significant effect in 2003. These results suggest, albeit weakly, that both types of IT—IT connectivity and research-related IT— influence publishing productivity. Within Tier 2, a puzzling result is the negative, statistically significant coefficient on DNS for 2001 and 2003.

Table 7 addresses the sectoral hypothesis, showing estimates of the differential effect of IT by tier along with the associated standard errors (calculated from Table 6). Table 8 provides estimates and standard errors of the differential effects for two general indicators of connectivity not discussed heretofore: whether the institution ever adopted BITNET and whether the institution was an early adopter of DNS.[28] Taken together, these findings provide some support for the sectoral hypothesis. Table 7 shows that IT, as measured by access to BITNET, had a positive and statistically significant differential effect on publishing in Tier 3 relative to Tier 1 in 1983. And IT, as measured by access

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[27]In Poisson regression, coefficients do not directly provide information about the magnitude of a variable's effect. The formula [(exp (B) -1) * 100], where B refers to the Poisson coefficient, provides information about magnitude in percent terms. Thus the coefficient of .46 in Table 6 implies that the publication counts of individuals at institutions with DNS were 58 percent [(exp(.46)-1) *100] higher than for individuals without this type of IT, controlling for demographic factors.

[28]The definition of early adoption builds on Rogers (2003) who classifies "innovators" as being in the first 2.5% of adopters and "early adopters" making up the next 13.5%. Here we classify any institution that fell into the first 16% as being an early adopter. The cut-off date for this definition of early adoption is June 1988.

to DNS, had a positive and significant differential effect on publishing in Tier 3 relative to Tier 2 in 2003. In other cases, the result is positive as expected and close to being significant at the 10 percent level; this includes the differential effect of BITNET in Tier 3 vs. Tier 1 in 1983 and the differential effect of DNS in Tier 3 vs. Tier 2 in 2001. An unexpected finding, contrary to the sectoral hypothesis, is that DNS increased publishing counts in Tier 1 relative to Tier 2 in 2001 and 2003. Turning to the results in Table 8, we see that IT,as measured by whether the institution ever adopted BITNET, had the expected impact on the publishing productivity of individuals at Tier 3 relative to Tier 1 institutions, but only in 1995. Furthermore, early adoption of DNS significantly increased publishing productivity in 2003: the differential effect is positive and statistically significant for Tier 3 vs. Tier 1 and Tier 3 vs. Tier 2.

Finally, Table 9 compares the difference in the publication rate of women vs. men with and without access to IT within tier, thereby testing the hypothesis regarding the "opportunity-enhancing" effect of IT. Across alternative specifications and SDR years, the findings provide no support for this hypothesis. And, quite puzzling, the interaction has a negative significant effect in the 2003 model estimated for Tier 3, where IT is indicated by the adoption of JSTOR.

We also performed several sensitivity tests. For example, we restricted the analysis to those who were at an early career stage and thus most likely to have been exposed to new technologies in graduate school or during post-doctorate appointments. The results were weak, likely due to the small sample size. Another concern mentioned earlier is that some researchers may have recently changed institutions and so publications early in the count period may reflect work done at a prior institution with different IT access. We found, however, that the results were not that different when the analysis was limited to those who had not changed institutions in the previous two years. We also estimated models that classify BITNET and the INTERNET (as measured by the presence of a domain name) as similar "connectivity" technologies. In these models, estimated using data for 1995, IT is specified as 1 if the institution had access to either BITNET or DNS. Once again, we found the results to be substantially the same as those reported in Table 6.

Finally, using data from the 1983 and 1995 SDR, we also analyzed the impact of IT on the average annual publication flow at the *institutional* level, within tier, using a difference-in-difference approach.[29] IT is found to have a positive and significant (10 percent level) impact on an institution's average research productivity for Tier 2, consistent with the "IT-enhancing hypothesis." The relationship is not significantly different from zero at conventional levels in the Tier 1 equation.

Conclusion

This study breaks new ground by examining the diffusion of multiple innovations in information technology across institutions of higher education. Consistent with the literature on diffusion of technology in other realms, we find that the diffusion patterns observed reflect, for the most part, the standard S-curve. We also find substantial variation in the pattern of diffusion by tier. The four IT indicators that we have developed—two reflecting "connectivity" and two reflecting "research-related IT"—were

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[29]We thank the editor for making this suggestion. In 1983, some institutions had access to BITNET as noted earlier, while others did not. In 1995, some institutions had adopted BITNET by 1990 or moved on to the Internet and had registered their domain names, while others had not. Using this variation, we estimated the following model by tier using ordinary least squares: an institution's average publication flow= Bo + B1 IT + B2 1995 + B3 IT*1995 + ε.

then used to investigate the determinants of publishing productivity of life scientists in the SDR. These results provide limited support in favor of the "IT-enhancing" and "sectoral" hypotheses. No evidence is found, however, that IT significantly affected the opportunities of women relative to men within tier (the "opportunity-enhancing" hypothesis).

What can explain these findings? First, the SDR does not provide publication information for the period from the mid-to-late 1980s. This means that the SDR data fail to capture the period when the adoption of IT may have had its most noticeable effects. It is exactly for this period that Agrawal and Goldfarb (2008) found that BITNET had a significant effect on publication productivity. Somewhat related, it is also possible that the early sectoral advantage that IT technologies provided did not persist over time.

Second, it may be that IT has its greatest effect on co-authorship patterns, not on individual productivity. Our data are simply not up to testing this hypothesis.[30] Third, it may simply be that during the period studied, IT was not as critical to success in the life sciences as it was in other fields.[31] A testable hypothesis for future work is that the availability of connectivity may have been less important in the life sciences than in other fields such as the social sciences.[32] In the life sciences, much of the work is done in the laboratory where physical proximity is crucial. In contrast, connectivity may provide a

[30] In a separate paper (Ding, , Levin, Stephan and Winkler, in process), we are exploring many of these issues by appending our measures of IT "connectivity" to longitudinal data (1969-1993) on the research productivity of life scientists. Advantages of these data are that they pre-date the IT revolution and span the period of the 1980s when connectivity was evolving.

[31] One would, however, expect IT to have become increasingly important in the biomedical sciences as large databases, such as GenBank and the Worldwide Protein Data Bank, have become available through web access.

[32] As mentioned earlier, due to the lack of publications data for the critical latter part of the 1980s, SDR data would not be well-suited for this purpose.

greater advantage in the social sciences such as economics, where researchers can more often meaningfully collaborate at a distance.

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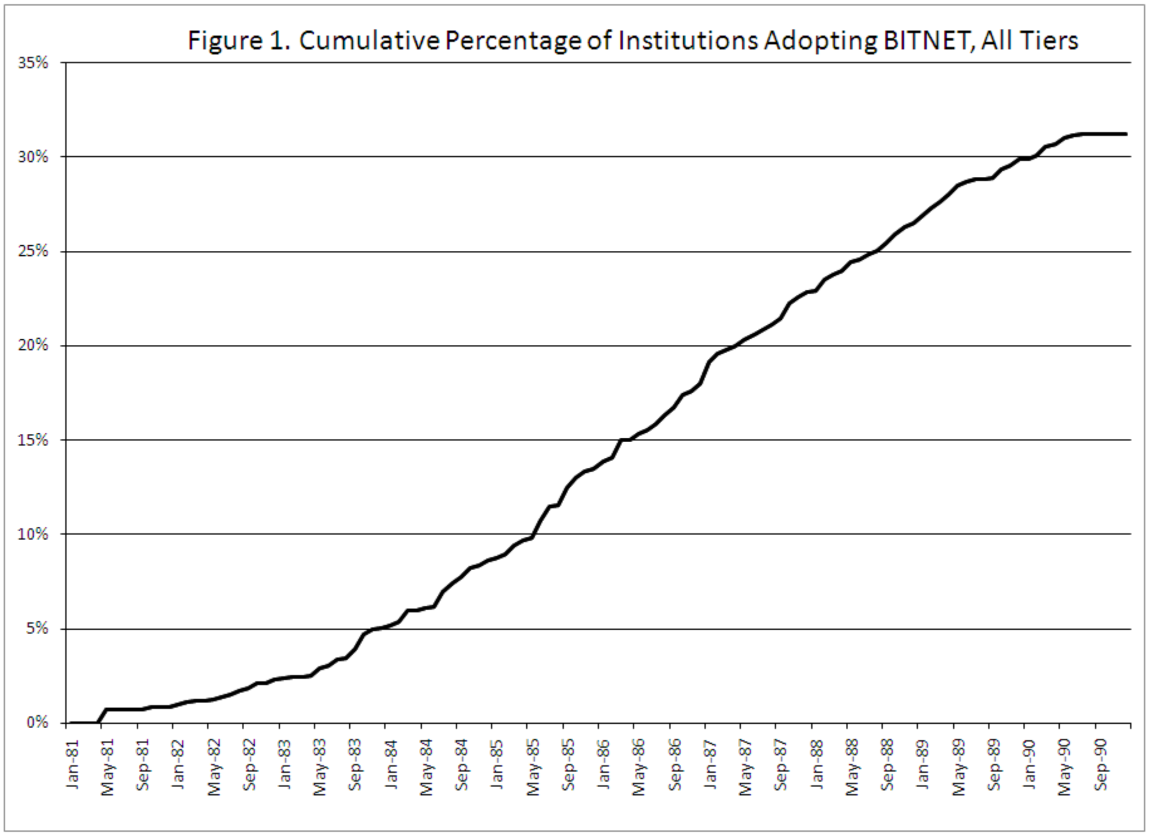
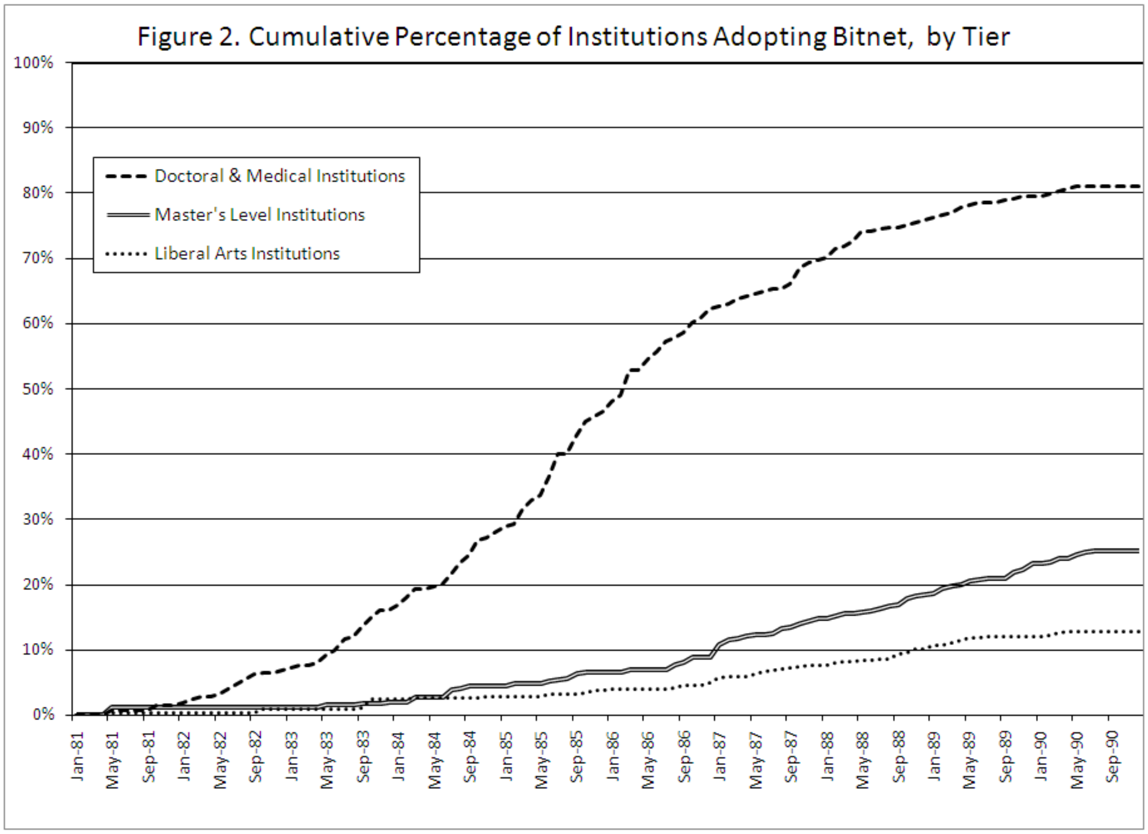
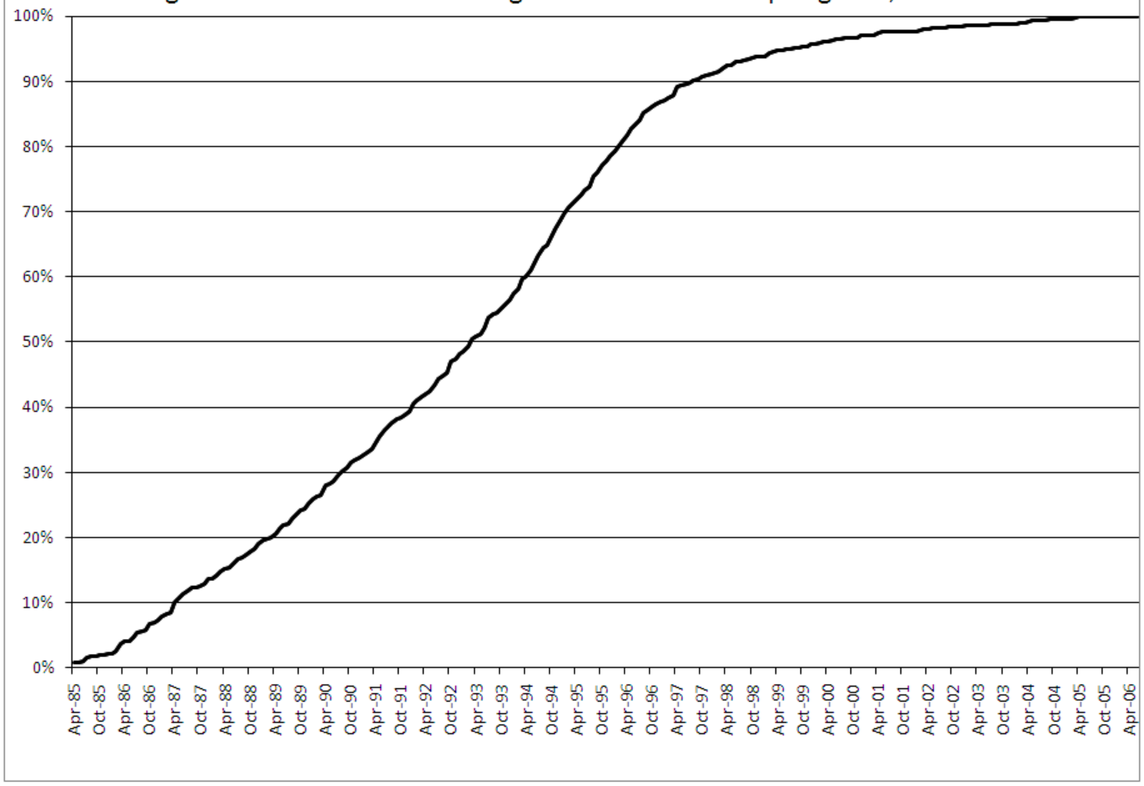


Source: Authors' calculations based on data from *Atlas of Cyberspaces*.

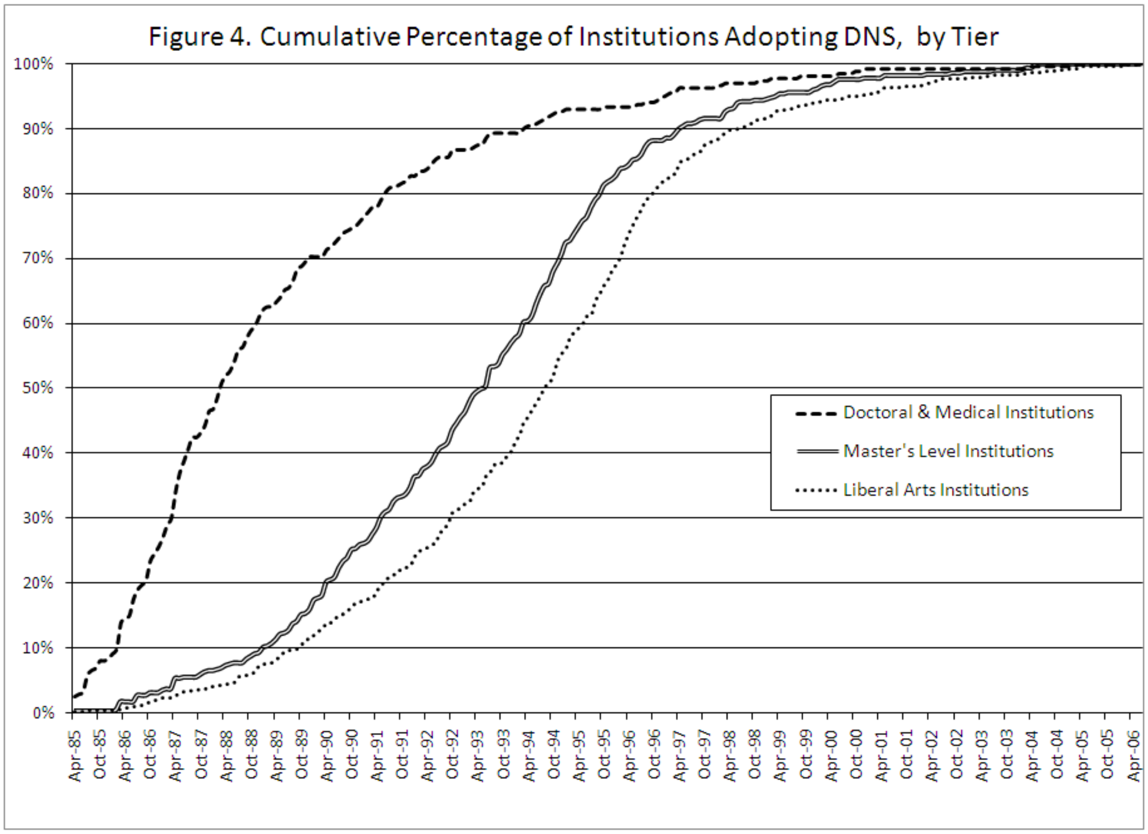


Source: Authors' calculations based on data from *Atlas of Cyberspaces*.

Figure 3. Cumulative Percentage of Institutions Adopting DNS, All Tiers



Source: Authors' calculations based on data from the *ALLWHOIS* domain name registry site.



Source: Authors' calculations based on data from the *ALLWHOIS* domain name registry site.

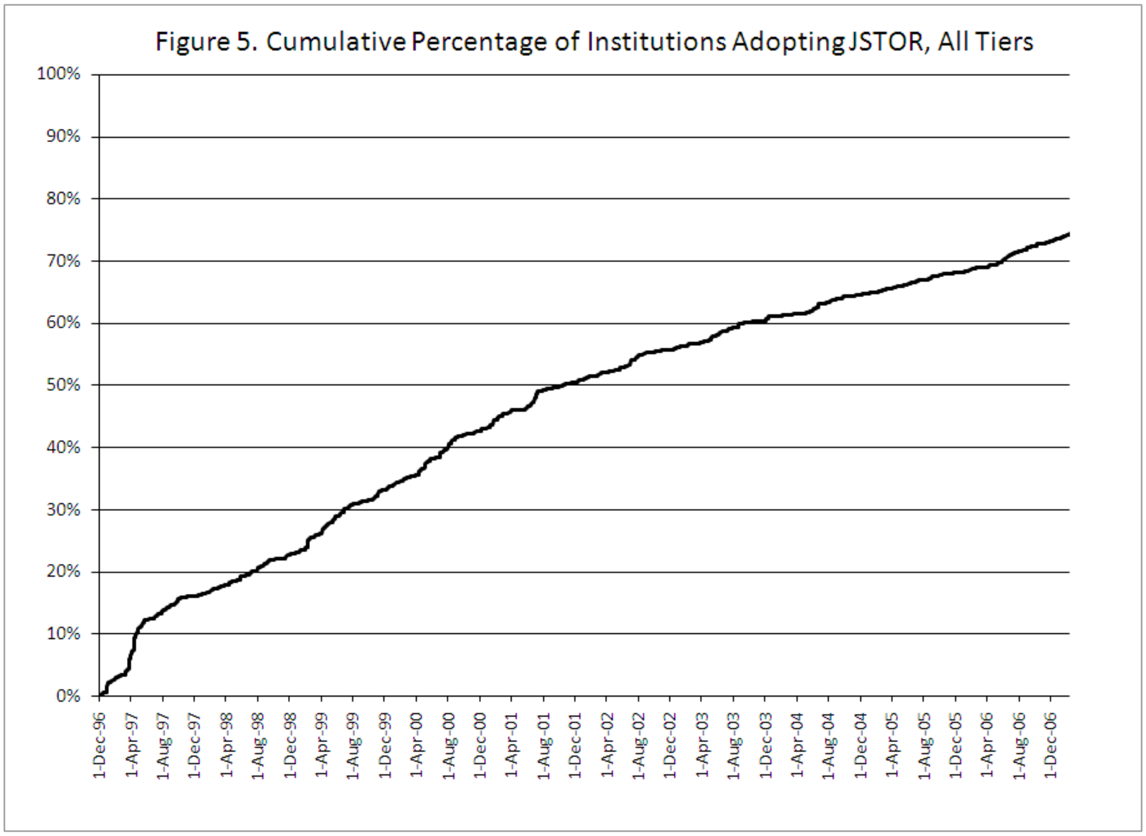
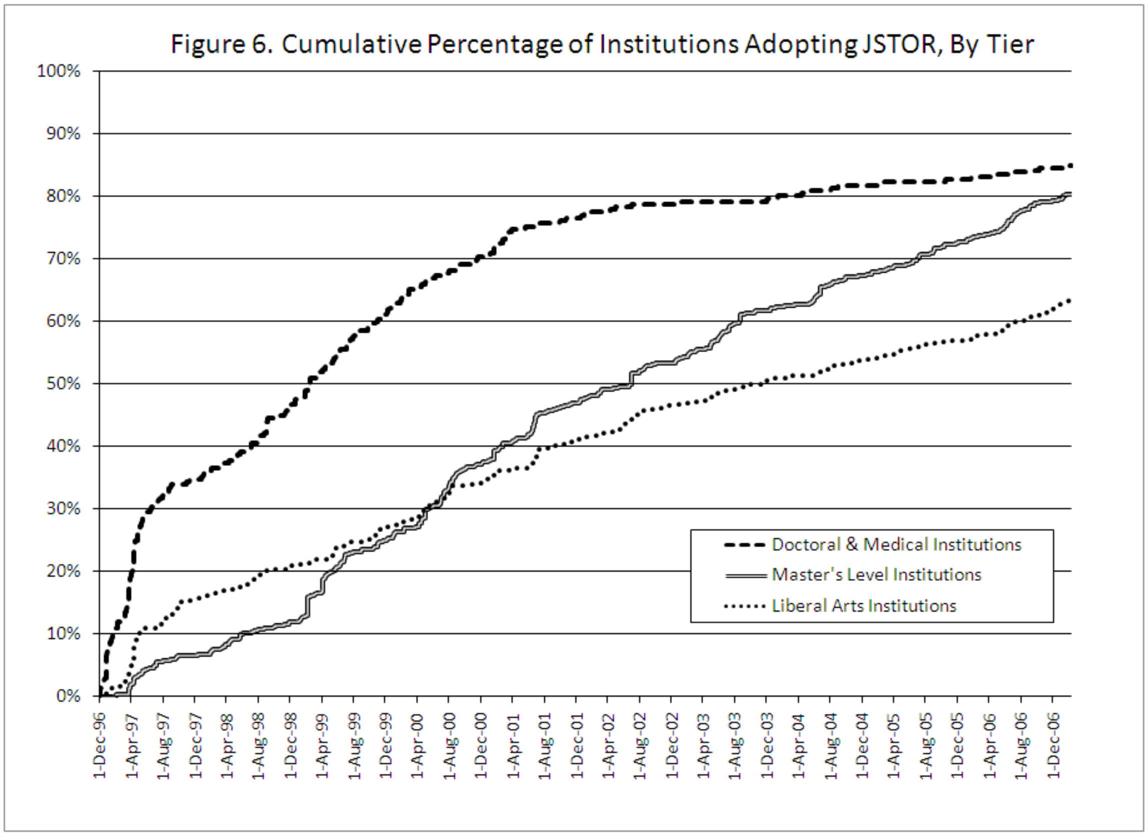
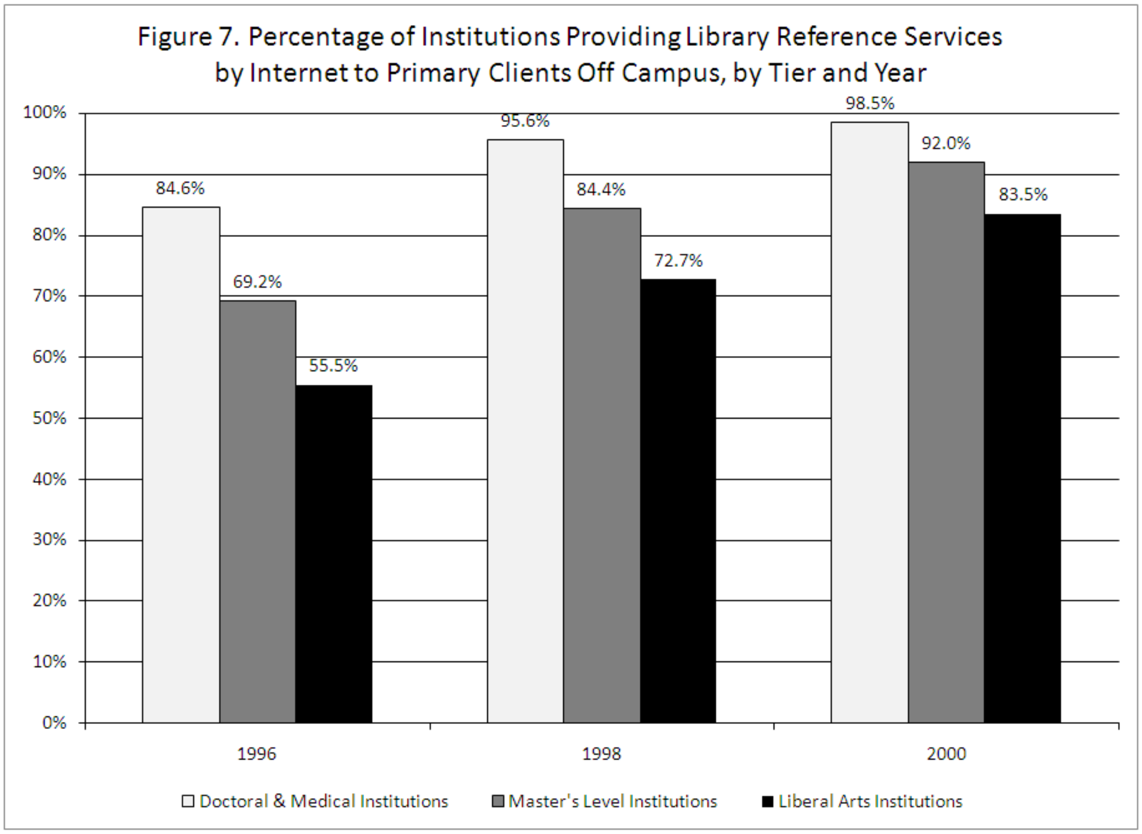


Figure 5. Cumulative Percentage of Institutions Adopting JSTOR, All Tiers

Source: Authors' calculations based on JSTOR data.



Source: Authors' calculations based on JSTOR data.



Source: Authors' calculations based on NCES data.

Table 1. IT Indicators Used in SDR Analysis

Period-Specific Measure of IT	Definition
1983 SDR (pubs. April 1981-April 1983)	
BITNET Available	1 if institution adopted Bitnet before 31 Dec. 1982; 0 else
1995 SDR (pubs. April 1990-April 1995)	
DNS Available	1 if institution adopted DNS before April 1989; 0 else
2001 SDR (pubs. April 1995-April 2001)	
DNS Available	1 if institution adopted DNS before April 1994; 0 else
Electronic Library Access	1 if electronic library resources available off-campus by 1996; 0 else
2003 SDR (pubs. Oct. 1998 - Oct. 2003)	
DNS Available	1 if institution adopted DNS before October 1997; 0 else
Electronic Library Access	1 if electronic library resources available off-campus by 1998; 0 else
JSTOR Available	1 if access to JSTOR available before October 1997; 0 else

Table 2. Detailed Statistics on Life Sciences

	2003	2001	1995	1983
Individual Characteristics				
Age	48.91	48.87	47.39	NA
Female (1= yes)	0.26	0.24	0.20	0.14
Presence of Child < 6 (1=yes)	0.18	0.17	0.19	NA
Never married (1=yes)	0.08	0.08	0.08	0.06
Race*				
White (1=yes)	0.82	0.85	0.89	0.91
Underrepresented minority (1=yes)	0.07	0.05	0.04	0.03
Asian (1=yes)	0.12	0.10	0.07	0.06
Noncitizen (1 = yes)	0.07	0.06	0.04	0.03
Employment Characteristics				
Experience (years since receiving Ph.D)	18.34	18.95	17.89	15.05
Career Stage				
Early (on tenure track, not yet tenured)	0.22	0.23	0.23	0.21
Mid (tenured, experience < 20 years)	0.24	0.21	0.24	0.44
Later (tenured, experience > 20 years)	0.36	0.39	0.39	0.26
Not applicable for position/employer	0.18	0.17	0.14	0.09
First job since doctorate (1=yes)	0.17	0.18	0.15	NA
Changed Employer in last 2 years (1=yes)**	0.09	0.08	0.08	NA
Publication Productivity				
Total Publication Count (during survey period)	9.62	10.83	9.47	4.80
Exposure (time at current institution during survey period)	4.32	5.05	4.38	2.00
Average annual publication flow	2.22	2.12	2.12	2.40
No publication (1 = yes)	0.11	0.12	0.10	0.23
Institution Characteristics				
Private university (1=yes)	0.32	0.32	0.30	0.24
Medical School	0.33	0.40	0.37	0.31
Tier of Institution				
Tier 1 (1=yes)	0.37	0.39	0.37	0.38
Tier 2 (1=yes)	0.40	0.41	0.43	0.41
Tier 3 (1=yes)	0.18	0.17	0.16	0.18
Tier 4 (1=yes)	0.05	0.04	0.04	0.03
Sample size (individuals)	1614	1834	2856	4447
Sample size (institutions)	526	530	620	663

Notes: All means are weighted.
Tiers used in the individual-level SDR analysis differ from those used in institutional-level figures.
Tier 1 refers to strong and distinguished ranked Ph.D. programs.
Tier 2 refers to other ranked Ph.D. programs plus doctoral programs.
Tier 3 refers to Master's, Comprehensive, plus top liberal arts.
Tier 4 refers to other liberal arts.
Persons in medical schools are assigned to either tier 1 or 2, depending on the quality of the Ph.D. program or NIH funding ranking.

Table 3. Adjusted Publication Count (publication flow per year of exposure) by Year, Tier, and Gender

	Tier 1		Tier 2		Tier 3		Tier 4	
	Pub flow	n	Pub flow	n	Pub flow	n	Pub flow	n
1983								
All	3.07	1758	2.55	1823	1.01	735	0.40	131
Male	3.17	1328	2.66	1415	1.06	474	0.44	73
Female	2.45	430	1.68	408	0.75	261	0.29	58
1995								
All	2.98	1110	2.02	1202	0.82	443	0.56	101
Male	3.17	863	2.14	961	0.92	295	0.60	65
Female	2.23	247	1.47	241	0.55	148	0.43	36
2001								
All	2.86	686	2.11	744	0.83	330	0.44	74
Male	3.02	484	2.27	560	0.88	229	0.52	50
Female	2.39	202	1.54	184	0.69	101	0.25	24
2003								
	2.88	585	2.40	628	0.93	325	0.47	76
Male	2.97	395	2.59	474	0.96	214	0.47	54
Female	2.67	190	1.74	153	0.86	111	0.47	22

Notes:

All Figures are weighted.

Tiers are defined in Table 2.

Table 4. Availability of IT by Tier for Life Scientists in SDR^a

Period-Specific Measures of IT	**Adoption Period**	Tier 1	Tier 2	Tier 3	Tier 4
1983 SDR (pubs. April 1981-April 1983)					
BITNET Available	Before 31 December 1982	0.20	0.03	0.02	0.00
1995 SDR (pubs. April 1990-April 1995)					
DNS Available	Before April 1989	0.84	0.70	0.15	0.09
2001 SDR (pubs. April 1995-April 2001)					
DNS Available	Before April 1994	0.96	0.88	0.74	0.29
Electronic Library Access	Before 1996	0.80	0.92	0.71	0.49
2003 SDR (pubs. Oct. 1998 - Oct. 2003)					
DNS Available	Before October 1997	0.99	0.97	0.93	0.85
Electronic Library Access	Before 1998	0.97	0.97	0.84	0.67
JSTOR Available	Before October 1997	0.70	0.39	0.16	0.10

Notes: Figures are weighted.
Tiers are defined in Table 2.
These figures are based on 1614 individuals in 2003; 1834 in 2001; 2856 in 1995; and 4447 in 1983.

Table 5. Poisson Models of Publication Counts, Period-Specific Measures of IT, All Tiers

	1983 SDR	1995 SDR	2001 SDR		2003 SDR		
DEFINITION OF IT Indicator:	BITNET Available	DNS Available	DNS Available	Elect. Lib. Access	DNS Available	Elect. Lib. Access	JSTOR Available
Model 1: IT, Female, and Covariates							
IT Indicator[a]	0.24 ***	0.47 ***	0.36 **	0.16	0.18	0.62 ***	0.34 ***
	(.09)	(.08)	(.14)	(.14)	(.22)	(.21)	(.07)
Female	-0.37 ***	-0.38 ***	-0.35 ***	-0.36 **	-0.20 ***	-0.19 ***	-0.20 ***
	(.05)	(.06)	(.07)	(.07)	(.08)	(.07)	(.08)
Log Pseudo-L	-21410	-18935	-16149	-16226	-11737	-11615	-11542
Wald Chi-sq	99.03	108.89	92.21	84.41	51.31	66.90	72.77
n	4447	2856	1834	1834	1614	1614	1614
Model 2: IT, Female, Tier, and Covariates							
IT Indicator[a]	0.02	0.07	-0.01	0.03	-0.16	0.23 *	0.03
	(.09)	(.06)	(.15)	(.1)	(.17)	(.13)	(.07)
Female	-0.29 ***	-0.31 ***	-0.36 ***	-0.36 ***	-0.19 ***	-0.18 **	-0.18 **
	(.05)	(.06)	(.07)	(.07)	(.07)	(.07)	(.07)
Tier2	-0.24 ***	-0.36 ***	-0.36 ***	-0.36 ***	-0.25 ***	-0.25 ***	-0.24 ***
	(.06)	(.06)	(.07)	(.07)	(.07)	(.07)	(.08)
Tier3	-1.18 ***	-1.30 ***	-1.34 ***	-1.34 ***	-1.28 ***	-1.24 ***	-1.25 ***
	(.12)	(.11)	(.11)	(.11)	(.10)	(.10)	(.10)
Log Pseudo-L	-19785	-17109	-14427	-14426	-10195	-10185	-10198
Wald Chi-sq	191.98	307.5	265.97	263.93	237.52	264.22	243.75
n	4316	2755	1760	1760	1538	1538	1538

Notes: Models are unweighted. Table reports poission coefficients and robust standard errors clustered around institutions (in parentheses). Dependent variable is publication count.

* significant at 10% level; ** significant at 5% level; *** significant at 1% level.

Models 1 and 2 include the following control variables: race, citizenship, marital status, presence of small children (except for 1983 SDR), individual's career stage, and indicator of private (vs. public) institution (see Appendix A for precise specification). These models also adjust for exposure (time at current institution).

Model 1 is estimated using individuals in all tiers. Model 2 is estimated using Tier 1, 2, and 3 only; Tier 1 is the omitted group.

[a] The definition of the IT indicator for each model is listed at the top of each model specification.

Table 6. Poisson Regression of Publication Counts, Period-Specific Measures of IT, By Tier

	1983 SDR	1995 SDR	2001 SDR		2003 SDR		
DEFINITION OF IT Indicator:	BITNET Available	DNS Available	DNS Available	Elect. Lib. Access	DNS Available	Elect. Lib. Access	JSTOR Available
Tier 1 Results:							
IT Indicator[a]	-0.01	0.04	0.46 ***	0.04	0.04	0.29 ***	0.01
	(.11)	(.10)	(.11)	(.14)	(0.39)	(.08)	(.10)
Female	-0.17 ***	-0.20 ***	-0.26 ***	-0.26 ***	-0.07	-0.07	-0.07
	(.08)	(.07)	(.10)	(.10)	(.10)	(.10)	(.10)
Log Pseudo-L	-9003	-7802	-6271	-6314	-4045	-4037	-4045
Wald Chi-sq	35.40	21.61	49.97	28.56	17.11	46.07	28.22
n	1758	1110	686	686	585	585	585
Tier 2 Results:							
IT Indicator[a]	0.00	0.04	-0.31 *	-0.07	-0.40 **	0.14	0.00
	(.17)	(.09)	(.16)	(.17)	(.17)	(.35)	(.12)
Female	-0.40 ***	-0.40 ***	-0.52 ***	-0.51 ***	-0.35 ***	-0.34 ***	-0.35 ***
	(.07)	(.09)	(.10)	(.10)	(.12)	(.12)	(.12)
Log Pseudo-L	-8685	-7351	-6126	-6161	-4494	-4511	4513
Wald Chi-sq	58.46	35.61	56.46	53.05	50.24	40.48	39.57
n	1823	1202	744	744	628	628	628
Tier 3 Results:							
IT Indicator[a]	0.59 *	0.11	0.11	0.08	0.26	0.32 *	0.36
	(.35)	(.22)	(.20)	(.22)	(.26)	(.17)	(.25)
Female	-0.58 ***	-0.54 ***	-0.09	-0.09	0.10	0.09	0.08
	(.14)	(.16)	(.26)	(.26)	(.19)	(.19)	(.18)
Log Pseudo-L	-2019	-1715	-1635	-1636	-1348	-1343	-1341
Wald Chi-sq	76.74	79.09	62.36	61.06	47.08	51.85	48.29
n	735	443	330	330	325	325	325

Notes. See Table 5. The full model results for 2001, where IT is measured as DNS available are provided in Appendix A.

[a] The definition of the IT indicator for each model is listed at the top of each model specification.

Table 7. Differential Effect of Period-Specific Measures of IT on Publication Counts
Dependent Variable: Publication Counts

	1983 SDR	1995 SDR	2001 SDR		2003 SDR		
DEFINITION OF IT Indicator:	BITNET Available	DNS Available	DNS Available	Elect. Lib. Access	DNS Available	Elect. Lib. Access	JSTOR Available
Differential Effect of IT Indicator[a]							
Tier 3 vs. Tier 1	0.61 *	0.07	-0.35	0.04	0.22	0.03	0.35
	(.37)	(.25)	(.23)	(.26)	(.27)	(.19)	(.27)
Tier 2 vs. Tier 1	0.01	-0.01	-0.77 ***	-0.11	-0.44 **	-0.15	-0.01
	(.21)	(.14)	(.19)	(.22)	(.19)	(.36)	(.16)
Tier 3 vs. Tier 2	0.59	0.08	0.41	0.15	0.67 **	0.18	0.36
	(.39)	(.24)	(.26)	(.27)	(.31)	(.39)	(.28)

Notes:
Estimates are obtained from Table 6 by differencing the coefficients on IT obtained from separate regressions by tier. For instance, the differential effect of IT in Tier 3 vs. Tier 1 of .07 shown in the upper left cell is equal to the coefficient on IT from the Tier 3 model .11 minus the coefficient on IT from the Tier 1 model .04 from Table 6.

[a] The definition of the IT indicator for each model is listed at the top of each model specification.

Table 8. Differential Effect of General Connectivity Indicators of IT on Publication Counts
Dependent Variable: Publication Counts

	1995 SDR		2001 SDR		2003 SDR	
DEFINITION OF IT Indicator:	Ever Adopted BITNET	Early DNS	Ever Adopted Bitnet	Early DNS	Ever Adopted Bitnet	Early DNS
Differential Effect of IT Indicator[a]						
Tier 3 vs. Tier 1	0.44 **	0.01	0.31	0.3	0.29	0.5 **
	(.20)	(.28)	(.25)	(.30)	(.27)	(.26)
Tier 2 vs. Tier 1	0.25	0.02	-0.01	0.02	0.19	0.05
	(.18)	(.13)	(.23)	(0.18)	(.25)	(.22)
Tier 3 vs. Tier 2	0.2	-0.01	0.32	0.28	0.1	0.45 **
	(.21)	(.27)	(.26)	(.27)	(.21)	(.22)

Note: See Note to Table 7. The poisson models from which these estimates are computed are not presented.
Ever Adopted BITNET = 1 if the institution adopted BITNET between 1981-and 1990; 0 otherwise.
Early DNS = 1 if the institution was one of the first 16% of adopters (i.e. adopted by June 1988); 0 otherwise.
[a] The definition of the IT indicator for each model is listed at the top of each model specification.

Table 9. Poisson Regression of Publication Counts, Period-Specific Measures of IT, By Tier, with Gender * IT interaction

	1983 SDR	1995 SDR	2001 SDR		2003 SDR		
DEFINITION OF IT Indicator:	BITNET Available	DNS Available	DNS Available	Elect. Lib. Access	DNS Available	Elect. Lib. Access	JSTOR Available
Tier 1 Results:							
IT Indicator[a]	-0.04	0.09	0.51 ***	0.02	-0.19	0.14	0.06
	(.13)	(.10)	(.12)	(.15)	(.53)	(.27)	(.13)
Female	-0.19 **	0.03	-0.07	-0.36 ***	-0.66	-0.66	0.06
	(.08)	(.19)	(.18)	(.14)	(.58)	(.44)	(.17)
Female*IT	0.12	-0.27	-0.2	0.11	0.59	0.6	-0.19
	(.20)	(.20)	(.21)	(.17)	(.58)	(.45)	(.20)
Log Pseudo-L	-9001	-7793	-6270	-6313	-4045.15	-4031	-4039
Wald Chi-sq	36.85	23.91	57.62	32.29	21.41	21.62	29.45
n	1758	1110	686	686	585	585	585
Tier 2 Results:							
IT Indicator[a]	0.08	0.03	-0.34 **	-0.06	-0.50 ***	-0.02	-0.02
	(.54)	(.09)	(.17)	(.18)	(.17)	(.39)	(.13)
Female	-0.38 ***	-0.42 ***	-0.69 **	-0.41	-0.86 **	-0.74 **	-0.39 ***
	(.07)	(.11)	(.29)	(.30)	(.42)	(.31)	(.14)
Female *IT	-0.59 ***	0.02	0.19	-0.11	0.53	0.43	0.12
	(.16)	(.15)	(.31)	(.31)	(.43)	(.31)	(.21)
Log Pseudo-L	-8680	-7351	-6124	-6161	-4488	-4507	-4512
Wald Chi-sq	152.96	40.65	57.79	53.23	55.94	50.40	47.37
n	1823	1202	744	744	628	628	628
Tier 3 Results:							
IT Indicator[a]	0.72	0.01	0.24	0.08	0.29	0.24	0.66 **
	(.58)	(.27)	(.24)	(.24)	(.24)	(.20)	(.30)
Female	-0.57 ***	-0.62 ***	0.31	-0.09	0.19	-0.25	0.25
	(.14)	(.17)	(.40)	(.46)	(.53)	(.48)	(.20)
Female *IT	-0.27	0.38	-0.55	0.00	-0.10	0.37	-0.93 **
	(.67)	(.37)	(.50)	(.51)	(.54)	(.50)	(.38)
Log Pseudo-L	-2018	-1713	-1630	-1636	-1348	-1342	-1326
Wald Chi-sq	78.25	79.56	64.42	61.67	48.54	51.08	51.53
n	735	443	330	330	325	325	325

Notes: See Notes to Table 5.

[a] The definition of the IT indicator for each model is listed at the top of each model specification.

Appendix A. Full Poisson Model Results, 2001 SDR, IT measured as adopted DNS by April 1994

	Tier1		Tier 2		Tier 3	
Intercept	-3.47	***	-2.96	***	-4.61	***
	(.13)		(.19)		(.19)	
Nevermarried	0.23		0.01		0.86	**
	(.19)		(.16)		(.42)	
Child < 6	0.06		-0.05		0.62	**
	(.10)		(.16)		(.30)	
Child<6 * Female	0.16		0.39		-0.75	*
	(.23)		(.27)		(.41)	
Unrepresented Minority	-0.05		-0.2		-0.38	
	(.16)		(.17)		(.27)	
Asian	0.02		0.11		0.09	
	(.13)		(.16)		(.46)	
Noncitizen	0.51	**	0.12		0.03	
	(.22)		(.24)		(.46)	
Early Career Stage	0.17		0.37	**	1.46	***
	(.15)		(.15)		(.29)	
Later Career Stage	-0.03		-0.2	*	-0.23	
	(.10)		(.12)		(.21)	
Career Stage N.A.	-0.04		0.16		0.81	**
	(.13)		(.18)		(.36)	
Female	-0.26	***	-0.52	***	-0.09	
	(.10)		(.10)		(.26)	
Private Institution	0.15		0.02		-0.52	**
	(.10)		(.13)		(.24)	
IT (DNS available)	0.46	***	-0.31	**	0.11	
	(.11)		(.16)		(.20)	
Pseudo Log-Likelihood	-6271		-6126		-1635	
Wald Chi-squared	49.97		56.46		62.36	
n	686		744		330	

Notes: Models are unweighted. Table reports poission coefficients and robust standard errors clustered around institutions (in parentheses). Dependent variable is publication count.
* significant at 10% level; ** significant at 5% level; *** significant at 1% level.
Omitted group for race is white; for career stage it is mid career.
These models also adjust for exposure (time at current institution).