*Technology Transfer and the Academic Department: Who Participates and Why?*

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Abstract: This paper examines faculty participation in university technology transfer using data on individual researchers from the medical schools of Duke University and Johns Hopkins University. The paper tests hypothesis about the effects of individual attributes, organizational incentives and social interactions on the decision to file academic disclosures, which signal a willingness to participate in technology transfer. Our results suggest that the adoption of initiatives like technology transfer is a function of the norms at the institutions where the individual trained; the observed behavior of their chairman and the observed behavior of similar individuals.

Keywords: university-industry technology transfer, organizational initiatives and change, social learning

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University technology transfer presents an interesting puzzle for economists who study science and technology. While economic growth is predicated on the creation and implementation of new knowledge and universities are an important source of that knowledge, there is great variation in the degree of commercialization of academic discoveries among universities (Nelson 2001). The relationship of university resources to a variety of technology transfer output measures is not straightforward (Siegel, Waldman, and Link, 1999; Thursby and Kemp, 1999). Moreover, technology transfer activity is typically concentrated in just a few academic departments within any university. This suggests that organizational factors influence participation in technology transfer. As a result, interest is shifting towards understanding the process of technology transfer and the mechanisms that enable universities to promote technological change.

The entire technology transfer process is predicated on individual faculty members disclosing their inventions or scientific discoveries to the university's technology transfer office. By filing an inventions disclosure, faculty members provide the raw materials for university intellectual property. If faculty members do not disclose research results then there is no technology available to patent, and subsequently license and transfer out of the university. While disclosing inventions is a requirement of federal funding, Thursby et al. (2001) note that difficulties in obtaining faculty disclosures is one of the main challenges for technology transfer offices.

Universities are social institutions and academic scientists are influenced by social norms and expectations (Geiger 1993). Indeed, university culture, once established, has proven enduring (Feldman and Desrochers, forthcoming) and historically there has been great institutional variation in acceptance of university patenting (Mowery and Sampat 2001). Nelson (2001) argues that the Bayh-Dole Act of 1980, which gave universities the right to retain ownership over intellectual property created by their faculty, represents a radical break with the prior norms of open science – rather than publish academic articles, scientists were encouraged to consider the potential commercial value of their discoveries. While some universities, notably Stanford and MIT, already had technology transfer offices and had achieved success with commercial activities, other universities were not previously active in tech transfer or moreover were hostile to the idea of commercial activity. For these universities, this new era of university technology transfer delineates an experiment in organizational change.

In this paper, we examine the disclosure behavior of individual faculty members at the medical schools of two prominent research universities, Johns Hopkins and Duke University. Both universities are late entrants to technology transfer, as defined by Mowery and Ziedonis (2002). Neither institution had significant technology transfer activity before the 1980 passage of the Bayh-Dole Act and did not establish dedicated technology transfer and licensing offices until the mid 1980s, well behind similarly ranked universities with medical schools (AUTM 2002). More recently, the administrations at both these universities have embraced technology-transfer as an institutional objective. During the decade of the 1990s they made substantial, yet varying, progress in carrying-out this new mission (Feller et al. 2000). Even though both universities have renowned medical schools, there is great variation in technology-transfer activities among individual academic departments. This suggests that social interactions and peer expectations influence participation in technology transfer.

This paper investigates the factors underlying individual faculty member's decision to disclose inventions to the technology transfer office. The next section draws upon the literature and the results of interviews with technology transfer managers and faculty members to develop a set of propositions about the individual faculty member's decision to disclose new inventions. The third section of the paper introduces the data and methodology and the fourth section provides empirical results.

**Invention Disclosures and Faculty Participation**

The Bayh-Dole Act requires faculty members to disclose inventions that result from federally funded research projects to the university's technology transfer offices along with information on the invention, the funding sources, potential licensees as well as barriers to patent protection such as prior publication. These disclosures are evaluated as to their patentability and commercial potential. On average, approximately 20% of disclosures are patented and about 10% of these patents are licensed to firms (Mowery and Ziedonis 2002).

The process of technology transfer involves at least three different stages with invention disclosure as the initiating stage (Thursby and Thursby 2002). After all, if individual faculty members do not disclose their inventions then there can be no patenting and no subsequent downstream licensing and licensing revenue. Without disclosures, regardless of the amount of resources, or the quality of the faculty at the institution, or any other measure of innovative inputs, the institution will simply not be productive at technology transfer. Thus the individual faculty member's decision to disclose their inventions is critically important to the process of technology transfer.

On face value, it seems that the decision to disclose research results should be straightforward. First, disclosing research results to the technology transfer office is a stipulation of federal research grants, the largest source of university research funding. In addition, to the extent that increased technology transfer activity is an articulated goal of university administrators we would expect encouragement for individual faculty members to participate. However, there are no objective standards that faculty members may use in evaluating if their discoveries warrant a disclosure to the technology transfer office.[1] Ambiguity exits as there are no clearly defined standards for what may be disclosed. To the extent that technology transfer managers are trying to encourage greater disclosure by faculty there does not appear to be screening that would discourage faculty participation. Indeed, Mowery, Sampat and Ziedonis (2000) note that only about 20% of disclosures were patented after six years, indicating that greater scrutiny accompanies the post-disclosure stage of the technology transfer process[2].

Thursby et al. (2001) argue that invention disclosures represent only a subset of university research with commercial potential. And, later suggest three reasons why faculty would choose not to disclose research results (Thursby and Thursby 2002). However each reason may be countered. First, it is claimed that faculty who specialize in basic research may not disclose because they are unwilling to spend time on the applied R&D required to interest businesses in licensing the invention. This is perhaps countered by the trend towards patenting basic scientific results from projects like the human genome. Second, faculty may not disclose inventions because they are unwilling to risk publication delays that may be required to interest industrial partners in licensing the technology. Interviews with both faculty members and TTO officials, however, indicate that this is more a perceptual problem than a reality. There are strategic ways to accommodate both academic and commercial interests but this requires a sophisticated understanding of the technology transfer process. Trusted peers who are familiar with the process can communicate strategies to accommodate both academic and commercial interests. Third, faculty members may not disclose because they believe that commercial activity is not appropriate for an academic scientist. This view certainly represents the older norms of academic science. However, to the extent faculty members disclose inventions; these norms appear to be changing.

Few studies have examined the internal process of disclosing academic inventions and the factors that underlie the decision to disclose. Table 1 demonstrates variation in disclosing behavior by academic departments within the medical schools at Duke University and Johns Hopkins University. These two universities are comparable: both had little experience with patenting and licensing prior to the passage of the Bayh-Dole Act. Both established dedicated technology transfer offices in the mid-1980s. In addition, both universities have well established and renowned medical schools. Medical schools account for the majority of university invention disclosures and are the focus of our analysis.

Departments at the two universities have slightly different names. We matched departments within the same field of inquiry and verified these matches with faculty members in the different

[1] Thursby and Thursby (2003) title a paper "The Disclosure and Licensing of University Inventions: Doing the best we can with the S**t we get to work with" – the title is taken from an interview with a tech transfer administrator who was bemoaning the quality of faculty disclosures. Historically there has been great variation in the types of inventions that were seen as patentable. For example, the University of Wisconsin founded the first technology transfer organization, the Wisconsin Alumni Research Foundation, around their vitamin patents while Johns Hopkins University decided that their vitamin discoveries belonged in the public domain.

[2] The cost of filing a patent is about $100,000 while the monetary costs associated with disclosure are negligible.

departments. As a first comparison, the number of faculty is provided for each department for the year academic year 1997-1998[3]. These are the individuals most likely to be in a position to disclose inventions[4]. In most cases the universities have a similar number of faculty within each department except for Cell Biology (Cell Anatomy and Biology) with 53 faculty members at Duke and 19 at Johns Hopkins, Ophthalmology with 34 at Duke and 119 at Hopkins and Neurobiology (Neuroscience) with 42 at Duke and 70 at Hopkins.

Technology transfer activity is concentrated within certain departments at the medical schools, as demonstrated by the number of faculty members filing disclosures. We might expect that technological opportunity would be greater in some fields than in others and that these high opportunity departments would have a similar share of faculty who disclosure inventions[5]. This does not appear to hold. For example, at Duke University approximately eight percent of the faculty who participated in tech transfer came from the cell biology department. In contrast, less than three percent of the participating Hopkins faculty was from the similar department. At Hopkins, ophthalmology accounted for almost ten percent of the disclosing faculty while only 3% of the Duke disclosing faculty was in the similar department. Even in OB/GYN, the one department where there are the same numbers of faculty at the two schools, the percentage of disclosing faculty differed substantially with a 3% rate at Duke compared to a 0.6% rate at Johns Hopkins.

What is rather striking is the variation in the number of disclosures normalized by department size or stated as the number of invention disclosure events per faculty member[6]. In aggregate, there were 0.384 disclosures per faculty member at Duke and 0.414 at Hopkins. However, there was great variation between departments. For example, on average, faculty in genetics at Duke –were involved in almost two disclosures each while radiology faculty involvement, on average, accounted for one-fifth of a disclosure.

The question becomes who discloses in the faculty, what are their characteristics and to what types of incentives do they respond? To develop hypotheses we rely on interviews with technology transfer officials and faculty members[7]. Given that the outcome of disclosing the invention in terms of profitability is uncertain, individual motivation appears to matter. We assume that every individual in the

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[3] These include Full Professors, Associate Professors, and Assistant Professors.

[4] Other individuals, such as staff, graduate students and post-docs may disclose inventions but this is a small percentage of the activity. It is more likely that disclosures that involve non-faculty have at least one faculty member listed as an inventor.

[5] The number of faculty members who have filed invention disclosures captures those who have disclosed in the three-year period, 1996-1998. This does not correspond directly to the absolute count of disclosure since more than one faculty member may be listed on a single disclosure. If a faculty member appeared on an invention disclosure they are counted as having filed a disclosure.

[6] We use the term invention disclosure events to capture the number of times that an individual was listed on an invention disclosure.

[7] To date, we have conducted over 70 interviews with technology transfer officials, university administrators and faculty members as background for this study.

medical school has an ability to disclose inventions. While we may expect that certain fields of research would be more amenable to disclosure, the lack of objective standards indicates it is an individual decision. We expect that faculty would be responsive to financial incentives and that there would be a direct relationship between licensing royalty distribution rates and the amount of technology transfer activity across universities. Our focus on departments within institutions holds these rates relatively constant since there is a convergence in incentives. Both universities we examine have a similar distribution rate with one-third of future revenue going to the individual faculty member, one third going to the central administration and one-third to the department. Departments "sweeten the deal" by distributing a share of their third of the royalties directly to the inventing faculty members' lab. This practice was first used to encourage tech transfer; however, it is now well established across departments in both universities.

In forming expectations about the benefits of disclosing, a faculty member may be influenced by prior experience, training and by observations of the actions of others in their professional network. Specifically, observational learning generates expectations that may influence an agent's subsequent actions (Manski 2000). Given that opportunity to disclose is uniform across fields and that the financial incentives are relatively constant, we test if observational learning through social interaction affects the preference of faculty members to disclose. We expect that the academic department would define the group that the individual would observe and consider relevant.

The decision to disclose appears to be influenced by three categories of interaction that we term training effects, chairman effects and cohort affects. Each of these is described below.

<u>Training effects</u>

Our interviews revealed that individuals who are trained at institutions where participation in technology transfer was accepted and actively practiced had an expectation of continuing this practice. There is a long literature on social imprinting that gives background on why the norms of training would form subsequent behavior. Interviews and anecdotal evidence add context. For example, one professor indicated that his graduate school mentors had disclosed and licensed their technology. He learned about disclosing by observing their experiences. While he recognized that the Hopkins culture did not at that time support technology transfer, he believed that disclosing would provide a vehicle for implementing his ideas. Similarly, William Brody, current president of Johns Hopkins, started as Assistant Professor of Radiology in 1972. He learned about tech transfer during his graduate study at Stanford University's Medical School and Department of Electrical Engineering. Once at Hopkins, he continued to actively disclosed inventions and subsequently started a company. His expectation was that tech transfer would be part of his career. In contrast, faculty who received their medical school training at institutions where technology transfer was not perceived as a legitimate activity appear to be less likely to disclose: they have no examples to follow, the process is unfamiliar and they may question the long-term impacts on the pursuit of science.

These training effects are likely to be mediated by the length of time an individual has been out of training. Technology transfer intensity among universities has increased over time. The earlier an individual completed her training, the more likely she is to have been exposed to, and adopted, the traditional norms of science that do not favor disclosing.

In addition, the breadth of an individual's training is expected to influence disclosure activity. Individuals who have acquired a broad knowledge base that supports multiple academic affiliations or those that have obtained both professional and academic degrees are more likely to embrace technology transfer activity. Entrepreneurial research has shown that individuals with interdisciplinary educational backgrounds and expansive prior knowledge are better positioned to recognize, and then act upon, innovation opportunities (Venkataramen, 1997; Shane 2000). Individuals who commonly encounter multiple theoretical perspectives in their professional role –boundary-spanners, for example – are more apt to be skilled in evaluating, integrating, and responding to diverse information (Cohen and Levinthal, 1990). Similarly, individuals who hold both a Ph.D. degree and a M.D. are expected to have training that encompasses research and practical application and will be better positioned to both develop new science and envision the commercial potential for such innovations.

Chairman Effects

Individual may adjust their expectations relative to the behavior of those in leadership roles. In academic departments, the leadership role is generally held by the department chairman. In medical schools the power and influence of the chair is particularly strong with long tenure. The chairman plays a direct role in reviewing and evaluating an individual's performance and making recommendations about promotion and tenure. One contentious issue is how technology transfer activity is treated in promotions and tenure[8]. The rules appear to be subjective and the problem for individual faculty members is to discern how their activity will be evaluated with limited information. One signal that the chairman is predisposed to consider disclosing as legitimate faculty activity would be the observed behavior of the chairman. Thus, if the chair is active in technology transfer as demonstrated by his prior disclosures, then he sends a signal that technology transfer is a valid activity. In this case, other members of the department would seemingly be more likely to disclose. We may expect that this signal would be stronger for junior faculty members who face greater uncertainty about expectations regarding promotion

[8] This was mentioned as a problem in several interviews. While the university may promote technology transfer if the department has not embraced it then the individual will face difficulties. There is no hard and fast rule for evaluating technology transfer activity relative to academic work. We have been told that the MIT electrical engineering department values a patent as much as an academic article in a high quality journal although there does not appear to be any quantification of these trade-offs at the two universities examined here.

and tenure. However, our interviews suggest that senior faculty members also benchmark their performance against the department chairman.

Cohort Effects

Prior studies show that learning activity is more likely to occur within a cohort of peers (Glaeser et al. 1996; Duflo and Saez 2000; Sorensen 2001). By observing the behaviors of others who are of similar status, an individual's expectations may change. We expect that individuals will be more likely to engage in technology transfer activities when they observe individuals with similar characteristics within their departments are also disclosing. While the department is expected to be the major social unit for learning about technology transfer, cohort effects may also transcend departments as individuals may relate to those they interact with in social settings or other venues.

The above discussion leads to three main predictions about faculty participation in technology transfer:

PREDICTION 1: Individuals whose graduate training incorporated technology transfer objectives will be more likely to disclose.

PREDICTION 2: Individuals in departments where the chair is actively involved in technology transfer are more likely to engage in technology transfer activities.

PREDICTION 3: Individuals are more likely to disclose if their peers engage in technology transfer activities.

**Data, Variables and Methods**

Our empirical analysis is based on an original database compiled from the technology transfer office records and other administrative data at Duke University and Johns Hopkins University. Our point of departure is the individual faculty member. We have data for faculty members across 15 departments in two medical schools for the academic years 1991-1999. We selected to examine medical school departments because most technology transfer activity originates within medical schools. We choose departments for which there was variation in disclosing rates across the universities. Our selection was constrained by the degree to which departments were present in both universities. Under the advice of medical school faculty, we selected matching departments – that is places where similar work was being done although the titles of the academic departments are slightly different.

The fifteen departments we use in our analysis are presented in Table 2. Our selection included medical school departments such as anesthesiology, pathology, radiology and surgery that are oriented toward providing patient services and are ancillary to other departments. These departments are termed nexus departments. Our interviews suggest that these departments may be in a position to engage in greater inventive activity. First, they interact with multiple departments and may learn about technology transfer from other faculty members. In addition, our interviews suggested that nexus departments also have the type of practical problem solving focus that promotes user-defined invention.

| Table2: Duke Medical School Departments | | | | |
|---|---|---|---|---|
| Duke Department (Chair has prior disclosures) | Department Type | Percentage of Faculty Disclosing in 1996-1998 | | |
| | | Full Professors | Associate Professors | Assistant Professors |
| Anesthesiology (no) | Nexus | 0.00% | 23.53% | 14.89% |
| Cardiology (yes) | Clinical | 33.33% | 30.77% | 16.67% |
| Cell Biology (yes) | Basic | 26.67% | 0.00% | 39.13% |
| Genetics (no) | Basic | 100.00% | 100.00% | 28.57% |
| Immunology (yes) | Basic | 53.85% | 20.00% | 25.00% |
| Microbiology (yes) | Basic | 37.50% | 0.00% | 25.00% |
| Ophthalmology (yes) | Clinical | 37.50% | 0.00% | 15.79% |
| Pathology (yes) | Nexus | 25.00% | 10.00% | 12.82% |
| Pharmacology (yes) | Basic | 23.08% | 25.00% | 47.06% |
| Radiolology (no) | Nexus | 23.53% | 5.26% | 12.00% |
| Neurobiology (yes) | Basic | 30.00% | 38.46% | 33.33% |
| OB/Gyn (no) | Clinical | 0.00% | 33.33% | 4.69% |
| Pediatrics (yes) | Clinical | 21.05% | 12.12% | 1.67% |
| Psychiatry (no) | Clinical | 9.68% | 7.31% | 2.56% |
| Surgery (no) | Nexus | 13.33% | 29.03% | 8.33% |

Our analysis also includes a set of clinical departments that provide primary patent care oriented toward a specific specialty, such as cardiology, ophthalmology, pediatrics or psychiatry. These departments include the largest numbers of medical school faculty. While these department names suggest routine patient care, the expectation is that faculty members will have a full research program.

Finally, we also examine basic science departments such as cell biology, genetics and immunology. These are areas in which we expect basic scientific discoveries that may lead to invention disclosures.

We use a three year window to track disclosures. This was chosen to capture a reasonable time period during which a faculty member might have results to disclose. Thus, we examine faculty who were at the university consistently from academic year 1996 -1997 to academic year 1998-1999. Personnel records, university course catalogues and archival data were used to build records for faculty members. Data on the disclosures and licenses are from the records of the technology transfer offices at the two universities.

Table 2 also presents disaggregated data for fifteen departments at Duke Medical School to demonstrate the variation in faculty disclosing behavior among academic departments. Table 2 further demonstrates the great variation in the rank of faculty members who disclose in each department. For example, nearly half of the junior faculty members in pharmacology disclosed in the three-year period, while all of the full and associate professors in the genetics department disclosed. The table also provides information on which department chairs had disclosures in the prior time period. Nine of the fifteen chairs had a history of disclosing.

To test our hypothesis, we estimate the effects of individual, chairman and cohort effects on the observed filing of disclosures. Table 3 summarizes the variables used to test our propositions and their predicted signs. The unit of observation is the individual faculty member and we are interested if the individual engaged in tech transfer by filing a disclosure. The dependent variable is equal to zero if the individual did not file an invention disclosure in the three year window for 1996-1998. The dependent variable is equal to one is the individual filed one or more disclosures during this period. The probability of disclosing is estimated using a PROBIT model.

*Training Effects*

We include two sets of variables to investigate training effects on faculty propensity to disclose. The first set of variables captures the likelihood that a faculty member was exposed to a pro-technology transfer culture during their training. Certain universities have historically had greater receptiveness to technology-transfer activities than others. Stanford is one well-known example, one that was mentioned numerous times in faculty interviews, of a pro-technology transfer university with a strong medical school. As such, we include a Stanford dummy variable equal to one if an individual has an advanced degree from Stanford, as our first measure of pro-technology transfer imprinting.

Table 3: Predictions for Measures for the Three Effects

| Greater propensity to disclose if | | Variable Description; | expected sign |
|---|---|---|---|
| Training Effects | P1a: Individuals trained with acceptance of technology transfer | **Where:** Stanford (1 = if graduate from Stanford; 0 = otherwise) | + |
| | | Early TTO (Graduate Institution had TTO before 1980 and demonstrated success with licensing) | + |
| | | **When:** Experience Years = years since last degree | - |
| | | **How trained:** Boundary spanning individuals | + |
| | | Dual Degree Individuals (PhD/MD) | + |
| Chairman Effects | P2a: Chair has history of disclosing | Chair has history of disclosing previously (1 = if yes; 0 = no) | + |
| | | Number of Chair's prior disclosures | + |
| Cohort Effects | P3: greater number of other faculty disclosures in department | Percentage of faculty members with disclosures in department cohort | + |

We create a second dummy variable that captures a broader set of universities known to have historically promoted technology transfer activities. Mowery and Ziedonis (2002) use the year of the establishment of a dedicated technology transfer office to categorize universities as incumbents or entrants. Among the 173 institutions that participated in the Association of University Technology Managers (AUTM) survey, the mean starting date for a dedicated tech transfer office was 1985. A simple cut would put those with a start date before the mean as early entrants. To measure the other dimension of the success at technology transfer activities we use licensing revenues received, an indicator of the degree of commercial receptivity to university inventions. While this measure is highly skewed by a relatively few successes it does carry a perception that the university is successful at tech transfer. The average licensing revenues for all institutions in 1996 were \$11.4 million with a standard deviation of \$14.0 million. As a simply categorization we consider universities with greater than average licensing revenue as successful at tech transfer. There were 14 institutions, as indicated in Table 4, which were both earlier entrants to technology transfer and achieved greater than average success. To the extent that student and alumni attitudes toward technology transfer are influenced by these two factors, we expect that individuals who trained at these universities will have a greater predisposition to technology transfer, ceteras paribus. We include a dummy variable that notes individuals who trained at the 13 institutions (omitting Stanford, which is tested separately) listed in Table 4.

Table 4: Universities with Strong Technology Transfer Orientation

| | Dedicated Technology Transfer Office before 1985 | Dedicated Technology Transfer Office after 1986 |
|---|---|---|
| Greater than Average Licensing Revenues in FY 1996 | California Institute of Technology<br>Columbia University<br>Harvard University<br>Iowa State University<br>Massachusetts Inst. of Technology (MIT)<br>Sloan Kettering Institute<br>Stanford University<br>University of California System<br>University of Florida<br>University of Minnesota<br>University of Rochester<br>University of Washington<br>W.A.R.F./University of Wisconsin-Madison<br>Yale University | |
| Less than Average Licensing Revenues in FY 1996 | | |

Source: Authors calculations from the Association of University Technology Mangers (AUTM) 1997 Annual Licensing Survey, FY 1996

Our final measure of pro-technology transfer exposure reflects the era in which in the faculty member was trained. As noted earlier, the acceptance of technology transfer activities at most universities has increased substantially over the past few decades. The more recent the faculty's training then, the more likely it is that the faculty member will have been introduced to the idea of active commercialization of research. We use a measure of experience years, calculated as the number of years since receiving their last advanced degree, to capture the timing effect associated with the individual's training.

The second set of training variables reflects the breadth of an individual's training. One sign of a breadth in training is the subsequent appointment of a faculty member to multiple departments. As such, we include a boundary spanning dummy variable, coded as one if the faculty member is associated with more than one department. A second indication of breadth in training is the attainment of multiple graduate degrees. Specifically, we include a dummy variable, coded as 1, to capture those individuals having both MDs and PhDs.

*Chairman Effects*

To explore the influence of the department chairman on faculty's propensity to disclose we use two measures of the chairmen's involvement in technology transfer. The first is a dummy variable indicating whether or not the chair has disclosed an invention to the technology transfer office in the prior five-year period, 1991-1995. This variable is coded 1 for yes, and 0 for no. To capture the intensity of the chairman's involvement, we also code a second variable that captures the number of times the chair has disclosed in the 1991-1995 period.

*Cohort Effect*

We define an individual's cohort as those individuals of the same rank in the same department. The cohort effect is measured as the percentage of faculty at the same rank within the department who disclosed in the prior time period.

*Control Variables*

We include several control variables in the estimation. First, disclosure behavior is expected to be influenced by the amount of resources available for scientific inquiry. Further we expect a lag between the receipt of research funding and the type of discovery that precedes an invention disclosure. To control for any such influence, we include a dollar measure of the NIH awards received by each faculty member in the previous five-year period. NIH funding is the most prominent source of medical school funding and carries the provision that invention disclosures be filed on the resulting discoveries. Second, we control for the number of previous disclosures (1991-1995) for each faculty member. We expect that those individuals that have disclosed in the past are likely to continue this behavior. Third, we include dummy variables to control for department type – basic science and nexus, with clinical as the omitted variable. Fourth, we add rank dummy variables to control for faculty rank. Finally, we include a university dummy variable to control for institutional differences between Duke and Johns Hopkins.

Descriptive statistics are presented in Table 5.

| Table 5: Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| | Number of Observations | Mean | Std. Deviation | Min | Max |
| Disclosure Filed in current time period | 1720 | 0.185 | 0.388 | 0 | 1 |
| Chair Discloses, prior time period | 1720 | 0.384 | 0.486 | 0 | 1 |
| Years Since Last Graduate Degree | 1720 | 19.730 | 10.722 | 0 | 47 |
| Full Professor | 1720 | 0.250 | 0.433 | 0 | 1 |
| Assistant Professor | 1720 | 0.442 | 0.497 | 0 | 1 |
| Boundary-Spanning Individual | 1720 | 0.315 | 0.465 | 0 | 1 |
| Double Degree, holds both PhD and MD | 1720 | 0.085 | 0.280 | 0 | 1 |
| Stanford Graduate Degree | 1720 | 0.013 | 0.112 | 0 | 1 |
| Graduate Degree from Pro-Tech Transfer University | 1720 | 0.148 | 0.355 | 0 | 1 |
| NIH Award Amount in prior period | 1720 | 575,882 | 1,776,736 | 0 | 1.96E+07 |
| Number of Previous Disclosures | 1720 | 0.519 | 1.784 | 0 | 31 |
| University (0 = Hopkins; 1 = Duke) | 1720 | 0.604 | 0.489 | 0 | 1 |
| Nexus Service Department | 1720 | 0.440 | 0.496 | 0 | 1 |
| Basic Science Department | 1720 | 0.124 | 0.329 | 0 | 1 |

**Results**

Table 6 provides results for all medical school faculty members in the selected departments at the two medical schools[9]. Model (1) provides a baseline model. The number of disclosures in the prior time period has a strong and statistically significant effect on disclosing in the current time period. This is, of course, to be expected as individuals tend to repeat established behaviors. Those who have previously disclosed are likely to continue this behavior, if the experience was reasonable. Faculty in basic science and nexus departments are significantly more likely to disclose than faculty in clinical departments, the omitted category. This may reflect the more patient oriented nature of departments like pediatrics and anesthesiology, however it should be noted that individuals in these departments do disclose inventions and the expectation at prominent medical schools is that all faculty conduct research. Academic rank, using the rank of associate professor as the omitted category, is not statistically significant. There is no evidence that disclosing varies consistently between full professors, associate professors and assistant professors. This result runs counter to the human capital argument that full professors, who are well established in their academic careers, will be more likely to leverage their reputations for commercial gain

[9] The sample size varies from the total reported in Table 1 due to missing data. Specifically, rank information is missing for 17 individuals. The sample size drops between Model 1 and Model 2 due to missing degreee/graduate school information.

(Stephan and Levin 1992). The amount of NIH funding is statistically significant, indicating that receiving funding increases the probability that an individual will disclose and complies with federal regulations. Finally, we find no significant differences between the two universities in this specification.

Table 6: Empirical Results: PROBIT Model: All Faculty

| | Model (1) | Model (2) | Model (3) | Model (4) | Model (5) |
|---|---|---|---|---|---|
| Years Since Last Graduate Degree | | -0.019<br>(0.004)** | -0.020<br>(0.004)** | -0.200<br>(0.004)** | -0.018<br>(0.004)** |
| Holds both MD and PhD degrees | | 0.399<br>(0.123)** | 0.378<br>(0.123)** | 0.378<br>(0.123)** | 0.388<br>(0.123)** |
| Boundary Spanning Training | | 0.174<br>(0.086)* | 0.161<br>(0.086)* | 0.167<br>(0.086)* | 0.174<br>(0.085)** |
| Stanford Degree | | 0.672<br>(0.325)* | 0.739<br>(0.312)** | 0.745<br>(0.314)** | 0.731<br>(0.314)** |
| Graduate Degree from Pro-Tech Transfer University | | 0.085<br>(0.109) | | | |
| Chairman Discloses | | | 0.253<br>(0.087)** | | |
| Number of Disclosures from Chairman | | | | 0.517<br>(0.180)** | |
| Cohort | | | | | 0.464<br>(0.258)* |
| NIH Awards | 0.040<br>(0.020) | 0.039<br>(0.022) | 0.038<br>(0.022)* | 0.035<br>(0.022) | 0.041<br>(0.021)* |
| Number of Prior Disclosures | 0.409<br>(0.031)** | 0.337<br>(0.032)** | 0.329<br>(0.032)** | 0.330<br>(0.032)** | 0.328<br>(0.032)** |
| Basic Science Department | 0.652<br>(0.099)** | 0.593<br>(0.120)** | 0.459<br>(0.129)** | 0.486<br>(0.126)** | 0.526<br>(0.128)** |
| Nexus Service Department | 0.270<br>(0.078)** | 0.210<br>(0.086)* | 0.206<br>(0.086)** | 0.184<br>(0.085)** | 0.175<br>(0.087)** |
| Full Professor | -0.014<br>(0.097) | 0.046<br>(0.114) | 0.046<br>(0.114) | 0.044<br>(0.114) | |
| Assistant Professor | -0.072<br>(0.081) | -0.078<br>(0.093) | -0.078<br>(0.093) | -0.084<br>(0.093) | |
| University dummy variable | 0.100<br>(0.070) | -0.126<br>(0.084) | -0.144<br>(0.085)* | -0.121<br>(0.085) | -0.144<br>(0.085)* |
| Constant | -1.567<br>(0.082)** | -0.989<br>(0.121)** | -1.029<br>(0.122)** | -0.998<br>(0.121)** | -1.078<br>(0.108)** |
| N | 2425 | 1720 | 1720 | 1720 | 1720 |
| Log Likelihood | -800.434 | -663.883 | -660.011 | -660.180 | -663.291 |
| Pseudo R2 | .1931 | .1937 | .1984 | .1982 | 0.1944 |

Model (2) builds on the basic specification by adding the training variables. Experience years, calculated as the number of years since the last graduate degree, is negatively and significantly related to participation in technology transfer: the probability of disclosing decreases by 1% for each year since the completion of graduate study. This result indicates that the earlier an individuals completed their training the less likely they are to pursue commercialization opportunities. Model 2 also adds in the influence of completing graduate training at historically pro-technology transfer institutions. The coefficient on the

Stanford dummy is positive and significant. Holding a Stanford degree increases the probability of engaging in technology transfer by 21%, all other things equal. Interestingly, we do not find any significant relationship between having trained at one of the other pro-technology transfer universities. It appears that the Stanford culture is truly unique.

Our measures of training breadth also contribute explanatory power. First, the coefficient on the dual degree dummy variable is positive and significant. Individuals having earned both an MD and a PhD show a greater propensity to disclose than their colleagues with single degrees. Holding both degrees increases the probability of disclosing by 10%. We also find a strong positive relationship between occupying a boundary position at the medical school and the likelihood of disclosure. Boundary spanning individuals, those with appointments in more than one academic department, are 4% more likely to disclose. These results are robust to departmental fixed effects as demonstrated in the appendix table.

Model (3) and (4) investigate the effect of the chairman disclosing behavior and finds evidence of a significant chairman effect. It appears that, to a significant degree, individual faculty model their technology-transfer behavior on the example set by their department chair. As shown in Model (3) if the chair has disclosed any inventions to the technology transfer office in the past five years, then the probability that the faculty member will disclose increases by 12%. Further, as shown in model (4), the likelihood of faculty disclosure increases with the intensity of chairman disclosure activity.

Model (5) considers the influence an individual's cohort has on disclosure activity. The coefficient on the cohort variable is positive and significant indicating that an individual's disclosure choice is swayed by the actions of those with similar rank within their department. We find that a 1% increase in the percentage of faculty disclosing within the relevant cohort increases the probability of an individual disclosing by 2%.

Table 7 presents the results of the model estimation on those individuals who are new participants to technology transfer. These are faculty members who filed their first invention disclosure in the three year time period 1996 – 1998. The empirical estimation, thus attempts to discern what influences this change in behavior. Model (1) begins with a basic specification. Again, we find that academic rank is not statistically related to disclosure and that disclosure is more likely for faculty associated with basic science and nexus departments. Though the baseline model shows a positive effect for level of NIH funding, this control loses significance with the addition of the proposition-related variables.

Results from Model (2), which adds the training variables to the baseline model, are consistent with the results found in the analysis in Table 6 for all faculty members. However, in this specification, we find that having trained at either Stanford or one of the other pro-technology transfer institutions has a positive significant effect on the likelihood of disclosure. This indicates that training has an effect on the decision to begin disclosing.

| Table 7: Empirical Results: PROBIT Model: Faculty members without prior disclosures<br>Dependent Variable = Disclosure filed (0,1) | | | | |
|---|---|---|---|---|
| | Model<br>(1) | Model<br>(2) | Model<br>(3) | Model<br>(4) |
| Chairman has filed invention disclosures | | | 0.235<br>(0.106)** | |
| Years Since Last Graduate Degree | | -0.019<br>(0.005)** | -0.020<br>(0.004)** | -0.206<br>(0.005)** |
| Holds both MD and PhD degrees | | 0.503<br>(0.145)** | 0.492<br>(0.145)** | 0.523<br>(0.144)** |
| Boundary Spanning Training | | 0.274<br>(0.101)** | 0.265<br>(0.100)** | 0.313<br>(0.098)** |
| Stanford Degree | | 0.686<br>(0.341)** | 0.671<br>(0.341)** | 0.742<br>(0.337)** |
| Graduate Degree from Pro-Tech Transfer University | | 0.200<br>(0.120)* | 0.186<br>(0.120)* | 0.237<br>(0.125)* |
| Cohort | | | | 0.633<br>(0.282)** |
| NIH Awards | 0.075<br>(0.031)** | 0.054<br>(0.034) | 0.054<br>(0.033) | |
| Basic Science Department | 0.735<br>(0.119)** | 0.541<br>(0.132)** | 0.402<br>(0.145)** | |
| Nexus Department | 0.347<br>(0.093)** | 0.272<br>(0.103)** | 0.283<br>(0.104)** | |
| University Control Variable | 0.115<br>(0.083) | -0.137<br>(0.097) | -0.148<br>(0.096) | -0.074<br>(0.095) |
| Full Professor | -0.004<br>(0.123) | 0.018<br>(0.142) | | |
| Assistant Professor | 0.012<br>(0.096) | 0.034<br>(0.108) | | |
| Constant | -1.754<br>(0.100)** | -1.218<br>(0.142)** | -1.246<br>(0.124)** | -1.113<br>(0.114)** |
| N | 2047 | 1443 | 1443 | 1443 |
| Log Likelihood | -549.225 | -468.701 | -442.348 | -475.261 |
| Pseudo R2 | 0.047 | 0.0863 | 0.0908 | 0.0736 |

Model (3) shows that the chairman effect is similar whether we consider the disclosure activity of all faculty or solely the subset of those faculty with no previous disclosure activity. Model (4) indicates a significant increase in the cohort effect for the later group. Individuals considering a change in behavior appear to be more susceptible to influence from their peers. Whereas for all faculty we find that a 1% increase in cohort activity drives an 2% increase in individual disclosure activity, for those with no history of disclosure a 1% increase in cohort activity translates to a 4% increase in new disclosure activity

**Conclusions and Further Research**

The results suggest that the decision to participate in technology transfer through the process of disclosing inventions is strongly influenced by training effects, chairman effects and cohort effects.

Individuals are more likely to disclose inventions if they trained at institutions at the forefront in terms of technology transfer benchmarking. Individuals who trained at institutions that have long established and relatively successful tech transfer operations are more likely to disclose their inventions. In addition, we find a negative career experience effect: the longer the time that had elapsed since graduate training, the less likely the faculty member was to actively embrace the new commercialization norm. We also find that where the chair of the department is active in technology transfer other members of the department are also likely to disclose. Most strikingly, technology transfer behavior is mediated by the experience of those in a similar position, in terms of academic rank and departmental affiliation. If an individual can observe others at their academic rank disclosing then they are more likely to disclose.

If we are going to think creatively about public policies towards increasing university technology transfer we need to reflective on the process of disclosing and to understand who discloses and why. With these initial steps we hope to begin an investigation.

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**References**


Banerjee, A.V. (1992). A Simple Model of Herd Behavior. *Quarterly Journal of Economics* 107(3): *797-817.*

Bercovitz, J. E. L, M. P. Feldman, I. Feller, and R. M. Burton. (2001). "Organizational Structure as a Determinant of Academic Patent and Licensing Behavior: An Exploratory Study of Duke, Johns Hopkins, and Pennsylvania State Universities." Journal of Technology Transfer, 26: 21-35.

Brock, W.A. and S.N. Durlauf (2001). Discrete Choice with Social Interactions. *Review of Economic Studies* 68(2): 235-260.

Cohen, W. M. and D. A. Levinthal, "Absorptive Capacity: A new perspective on learning and innovation," *Administrative Science Quarterly*, v. 35 (1990), p. 128 – 152.

Duflo E.and E. Saez (2000). Participation and Investment Decisions in a Retirement Plan: The Influence of Colleagues Choices. Mimeo.

Feldman, M. P. and P. Desrochers. (forthcoming) "Truth for Its Own Sake: Academic Culture and Technology Transfer at the Johns Hopkins University." *Minerva.*

Feldman, M. P., I. Feller, J. E. L. Bercovitz and R. M. Burton. (2002) "Equity and The Technology Transfer Strategies of American Research Universities. *Management Science.* 48: 105-121.

Feller, I., M. Feldman, and J. Bercovitz and R. Burton (2000). A Disaggregate Analysis of University Patent and Licensing Behavior. mimeo.

Geiger, R. L.,(1993). *Research and Relevant Knowledge : American research universities since World War II* (New York : Oxford University Press).

Geroski, P.( 2000). Models of technology diffusion. *Research Policy*, 29 (4-5): 603-625.

Glaeser, E.L., B. Sacerdote, and J.A. Scheinkerman (1996). Crime and Social Interactions. *Quarterly Journal of Economics* 111(2): 507-548.

Jensen,R.A. and J.G. Thursby and M.C. Thursby. (2003). The Disclosure and Licensing of University Inventions: "the Best we ca do with the s**t we get to work with" April 15, 2003.

Mazzoleni, Roberto, and Bhaven N. Sampat. (2002). University Patenting: An Assessment of the Causes and Consequences of Recent Changes in Strategies and Practices. *Revue d'Economie Industrielle* 0, no. 99:233-248.

Mansfield, E. (1961), Technical change and the rate of imitation. *Econometrica* 29(4):741-66.

Manski, C.F. (2000). Economic Analysis of Social Interactions. *Journal of Economic Perspectives* 14(3): 115-136.

Mowery, D., R. Nelson, B. Sampat and A. Ziedonis (1999) "The Effects of the Bayh-Dole Act on U.S. University Research and Technology Transfer" in Industrializing Knowledge, edited by L. Branscomb, F. Kodama, and R. Florida, (Cambridge, MA: MIT Press), 269-306.

Mowery, David C. and A. Ziedonis (1999), "The Effects of the Bayh-Dole Act on U.S. University Research and Technology Transfer: Analyzing Data from Entrants and Incumbents" Paper presented at the Science and Technology Group, NBER Summer Institute (Cambridge, MA: National Bureau of Economic Research).

Mowery, David C., and Arvids A. Ziedonis. (2002). Academic Patent Quality and Quantity before and after the Bayh-Dole Act in the United States. *Research Policy* 31, no. 3:399-418.

Mowery, David C., and Bhaven N. Sampat. (2001). University Patents and Patent Policy Debates in the USA, 1925-1980. *Industrial and Corporate Change* 10, no. 3:781-814.

Nelson, Richard R. (2001). Observations on the Post-Bayh-Dole Rise of Patenting at American Universities. *Journal of Technology Transfer* 26, no. 1-2:13-19.

Nygaard, A and R. Dahlstrom. (2002). "Role Stress and Effectiveness in Horizontal Alliance," *Journal of Marketing*, 66(2): 61-82.

Rogers, E. M. (1983). Diffusion of innovations, 3rd Ed. New York: Free Press.

Shane, Scott (2000). "Prior Knowledge and the Discovery of Entrepreneurial Opportunities," *Organization Science*, 11(4): 448-469.

Siegel, Don, D. Waldman and A. Link (1999) "Assessing the Impact of Organizational Practices on the Productivity of University Technology Transfer Offices: An Exploratory Study", Working Paper 7256, (Cambridge, MA: National Bureau of Economic Research).

Sorensen, A.T. (2002). Social Learning in the Demand for Employer-Sponsored Health Insurance. Mimeo.

Stephan, P.E. and S.G. Levin (1992). *Striking the mother lode in science : the importance of age, place, and time* (New York : Oxford University Press). Thursby, Jerry G., and Sukanya

Kemp. (2002). Growth and Productive Efficiency of University Intellectual Property Licensing. *Research Policy* 31, no. 1:109-124.

Thursby, J.G. and M.C. Thursby. (2003). “Patterns on Research and Licensing Activity of Science and Engineering Faculty”, April 2003.

Thursby, Jerry G., Richard Jensen, and Marie C. Thursby. (2001). Objectives, Characteristics and Outcomes of University Licensing: A Survey of Major U.S. Universities. *Journal of Technology Transfer* 26, no. 1-2:59-72.

Van de Ven, A. H. (1986). Central problems in the management of innovation. *Management Science* 32: 59-607.

Venkatarman, S. (1997). “The Distinctive Domain of Entrepreneurship Research: An Editor’s Perspective,” in Advances in Entrepreneurship, Firm Emergence, and Growth. J. Katz, R. Brockhaus, eds. JAI Press, Greenwhich, CT.

## Table 1: Invention Disclosures are Concentrated in Different Departments within Medical Schools

| Duke Department | Hopkins Department | Number of Faculty Members | | Number of Faculty Members who have filed Invention Disclosures | | | | Number of Invention Disclosure Events | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Duke | JHU | Duke | Percentage of Disclosing Faculty | JHU | Percentage of Disclosing Faculty | Duke | Disclosure Events per Faculty Member | JHU | Disclosure Ever per Faculty Member |
| esthesiology | Anesthesiology | 76 | 88 | 12 | 7.36% | 13 | 7.43% | 27 | 0.355 | 23 | 0.261 |
| rdiology | Cardiovascular Division/Medicine | 43 | 39 | 11 | 6.75% | 10 | 5.71% | 26 | 0.605 | 48 | 1.231 |
| ll Biology | Cell Anatomy and Biology | 53 | 19 | 13 | 7.98% | 5 | 2.86% | 49 | 0.925 | 9 | 0.474 |
| netics | Molecular Biology and Genetics | 12 | 25 | 7 | 4.29% | 4 | 2.29% | 23 | 1.917 | 53 | 2.120 |
| munology | Immunology | 40 | 16 | 14 | 8.59% | 9 | 5.14% | 42 | 1.050 | 18 | 1.125 |
| crobiology | Biological Chemistry | 37 | 37 | 5 | 3.07% | 4 | 2.29% | 13 | 0.351 | 11 | 0.297 |
| hthalmology | Ophthalmology | 34 | 112 | 5 | 3.07% | 17 | 9.71% | 13 | 0.382 | 130 | 1.161 |
| thology | Pathology | 62 | 91 | 11 | 6.75% | 20 | 11.43% | 25 | 0.403 | 70 | 0.769 |
| armacology | Pharmacology and Molecular Science | 38 | 25 | 13 | 7.98% | 13 | 7.43% | 43 | 1.132 | 40 | 1.600 |
| diolology | Radiolology | 61 | 84 | 8 | 4.91% | 10 | 5.71% | 13 | 0.213 | 27 | 0.321 |
| urobiology | Neuroscience | 42 | 70 | 14 | 8.59% | 22 | 12.57% | 32 | 0.762 | 53 | 0.757 |
| 3/Gyn | OB/Gyn | 85 | 85 | 5 | 3.07% | 1 | 0.57% | 8 | 0.094 | 8 | 0.094 |
| diatrics | Pediatrics | 121 | 246 | 11 | 6.75% | 19 | 10.86% | 14 | 0.116 | 28 | 0.114 |
| ychiatry | Psychiatry | 158 | 191 | 9 | 5.52% | 5 | 2.86% | 19 | 0.120 | 17 | 0.089 |
| rgery | Surgery | 194 | 258 | 25 | 15.34% | 23 | 13.14% | 58 | 0.299 | 39 | 0.151 |
| | Total | 1056 | 1386 | 163 | 100.00% | 175 | 100.00% | 405 | 0.384 | 574 | 0.414 |

| Appendix Table: Empirical Results: PROBIT Model:<br>Training Effects All Faculty with Department Fixed Effects<br>Dependent Variable = Disclosure filed (0,1)<br>Basic Science Omitted | |
|---|---|
| | Fixed Effects Model |
| Years Since Last Graduate Degree | -0.017<br>(0.004)** |
| Holds both MD and PhD degrees | 0.369<br>(0.124)** |
| Boundary Spanning Training | 0.186<br>(0.088)** |
| Stanford Degree | 0.691<br>(0.317)** |
| NIH Awards | 4.23<br>(2.11)** |
| Anesthesiology Department | -0.308<br>(0.162)* |
| Cardiology Department | -0.116<br>(0.192) |
| Ophthalmology Department | -0.293<br>(0.181) |
| Pathology Department | -0.355<br>(0.161)* |
| Radiology Department | -0.444<br>(0.181)** |
| Obstetrics Department | -0.921<br>(0.226)** |
| Surgery Department | -0.564<br>(0.133) |
| Neurology Department | 0.093<br>(0.235) |
| Pediatrics Department | -0.652<br>(0.147)** |
| Psychiatry Department | -0.907<br>(0.172)** |
| University dummy variable | -0.119<br>(0.085) |
| Number of previous Disclosures | 0.321<br>(0.032)** |
| Constant | -0.423<br>(0.141)** |
| N | 1720 |
| Log Likelihood | -649.733 |
| Pseudo R2 | 0.2109 |