Patterns of Research and Licensing Activity of Science and Engineering Faculty[1]

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April 2003

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[1] Financial support was provided by National Science Foundation (SES 0094573) and the Alan and Mildred Peterson Foundation.

Section 1. Introduction

The importance of university research for industrial innovation is widely accepted, so much so that any changes in the research environment tend to spark controversy. The recent increase in university licensing is no exception. The 84 universities responding to the Association of University Technology Managers (AUTM) Survey in 1991 and 2000 reported that invention disclosures increased 84 percent, new patent applications increased 238 percent, licenses executed increased 161 percent, and royalties increased 520 percent over the period. While technology managers and university administrators cite such figures as evidence of the increasing contribution of universities to the economy, skeptics question the impact of licensing on the conduct of university research.

Central to the debate is faculty behavior. Proponents of licensing argue that without the incentives it provides, neither faculty nor companies would undertake the development needed for many results of federally funded research to be transferred to industry. This, of course, is the key premise underlying the Bayh-Dole Act, which since 1980 has allowed universities to own and license results of federally funded research. Critics of the Act claim that academic publication would be sufficient for industry to pick up university inventions, and more importantly, they express concerns that potential financial returns from licensing have diverted faculty from more basic to applied research.

Three major issues related to faculty behavior are important for understanding the implications of licensing for the science and technology enterprise:

i. Does this observed increase in university licensing reflect a shift away from fundamental research or simply an increased willingness of faculty to have their work licensed as well as published (or both)? It is the former that has been discussed as an "unintended" effect of the Bayh-Dole Act in recent Congressional hearings as well as the National Academies Committee on Science, Engineering, and Public Policy (COSEPUP). The Act was intended, not to redirect faculty research, but rather to facilitate industrial application of university research.

ii. How is the propensity of faculty to disclose inventions related to individual characteristics (e.g., publication record, research sponsorship), and other characteristics (e.g., academic discipline, university and/or department effects)?

iii. What is the life-cycle behavior of faculty with respect to research, publication, and license-related activity? Evidence on life-cycle productivity will contribute to a better understanding of the science and technology enterprise, in general, as the age distribution of scientists and engineers changes (National Science Board 2000).

We know remarkably little about these issues, in large part because the literature on university licensing has focused on disclosures, patents, and licenses aggregated by field or university rather than the performance of individual inventors. We do not know even the portion of faculty who engage in licensing, much less their personal and research characteristics as compared to faculty who do not engage in licensing. In this paper, we attempt to redress this problem by examining the personal and research characteristics of a large sample of science and engineering faculty at six major universities.

The database we examine has the publication, disclosure,[2] and personal profiles of 3,241 faculty members at Cornell University, MIT, University of Pennsylvania, Purdue University, Texas A&M University and University of Wisconsin – Madison over a seventeen-year period. These data allow us to examine the evolution of faculty research and licensing behavior over time and the extent to which it is related to individual characteristics such as age or to environmental factors such as academic quality of their department. Further, we can address differences in patterns across universities and across disciplines in the life and physical sciences, as well as engineering.

Section 2. What do we know about licensing and faculty behavior?

There is a growing body of evidence suggesting that, for many inventions, technology transfer would be difficult at best in the absence of incentives provided by patent licensing. Recent surveys show that the overwhelming majority of university inventions are so embryonic that commercial application

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[2] A disclosure is a formal document that a faculty member files when it is believed that a potentially commercializable invention has been made.

requires, not only further development, but also faculty cooperation in that development (Thursby *et al.* (2001), Agrawal and Henderson (2002), Thursby and Thursby (2002)). Jensen and Thursby (2001) show that, to the extent that faculty prefer research to development, financial incentives are needed to induce them to work with licensees in further development. The emerging picture is that while some inventions, particularly those needing little development or faculty involvement (see Colyvas et al. (2002), would be transferred in the absence of licensing, the most embryonic might not.[3]

We know little, however, about the effect of licensing on faculty research as the literature on industry-university collaboration and research relates primarily to consulting and sponsored research, and the evidence is mixed. While some studies suggest that applied research has increased recently (Cohen *et.al* 1994, Morgan *et.al* 1997, Rahm 1994) others point to a long history of such research (Mowery *et.al* 2001, Rosenberg and Nelson 1994). Cohen *et al's* (1994) survey of university-industry research centers (UIRCs) provides evidence of the countervailing effects of industry collaboration on faculty productivity, with so-called commercial outputs of research increasing and publications decreasing (except in biotechnology). Given the importance of publications for industrial productivity (Adams 1990), these results are cause for concern. By contrast, Mansfield (1995), Zucker *et al.* (1994, 1998), Stephan *et al.* (2002), and Murray (2002) find a complementary relationship between research productivity and commercial activity. Mansfield's (1995) study of 321 academic researchers found that faculty in his sample frequently worked on basic problems suggested by their industrial consulting. Similarly, Zucker *et al.* (1994, 1998) found that the most productive scientists in biotechnology tend to capitalize on commercial applications of their basic research, starting new biotech enterprises while continuing research in their academic appointments. In the case of tissue engineering, Murray (2002) shows that many results are both patented and published.

Stephan *et al.* (2002) come the closest to examining our questions of interest. Using individual level data from the 1995 Survey of Doctorate Recipients, they examine the relationship of patents and publications, as well as life cycle and other individual effects. They find a complementary relationship for

[3] With regard to firm incentives to invest, Decheneux et al. (2003) provide evidence based on inventions licensed from MIT that the ability to appropriate returns via effective patent protection is an important determinant of whether or not firms will commercialize university inventions.

patents and publications, with the relationship being strongest for engineers. They also find that non-tenured faculty are more likely to patent than tenured faculty. For our purposes, the cross sectional nature of these data are a drawback. Further, while patents clearly signal faculty willingness to engage in licensing activity, the use of patents excludes information about faculty whose inventions are licensed but not patentable. Their approach also excludes observations on faculty who show an interest in licensing by disclosing inventions but whose inventions are not deemed commercially viable (and as a result are not patented).

Only a few studies examine invention disclosures and faculty research. Lach and Shankerman (2002) find a positive relationship between invention disclosures and the share of license revenue accruing to inventors. While they interpret this as showing the responsiveness of research to financial incentives associated with licensing, we argue that disclosures show the faculty's willingness to disclose results to the technology transfer office and may or may not reflect changes in research agendas. In Thursby and Thursby (2002), we examine whether the growth in university licensing is due to productivity of observable inputs or driven by an unobservable change in the propensity of faculty and administrators to engage in license-related activity. Our results suggest that changes in the direction of faculty research are relatively less important than other factors, such as a dramatic increase in the propensity of administrators to patent and license inventions, as well as increases in business reliance on external R&D. The problem with this analysis is that the data are not at the level of the individual scientist, but rather research outputs at the university level.

To our knowledge, there are no empirical studies of the relation between licensing activity and research productivity at the level of the individual inventor. However, recent theoretical work has examined the faculty member's choice problem when her income is a function of license revenue as well as her university salary. Jensen and Thursby (2003) examine a model in which faculty choose the amount of time to spend on basic and applied research given their salary and the share of license income they receive. In their model, faculty enjoy both the puzzle-solving aspects of research (see Hagstrom 1965 and Stern 1999) as well as the prestige associated with successes in their research (see Stephan 1996). The model also allows for research in the so-called "Pasteur's Quadrant," where a researcher's basic research produces both patentable and scientific knowledge, as well as the type of research characterized by Mansfield in which applied research has a positive impact on the researcher's basic research agenda (Mansfield 1995 and Stokes 1997). They show that increases in the share of license income will lead the faculty to change the amount of time they devote to applied and basic research only if the reallocation increases a “composite” marginal rate of substitution of applied for basic research. This composite rate of substitution incorporates not only pure utility effects, but also the extent to which a reallocation of research effort affects their productivity in generating reputation and income. They show that faculty who specialize in basic research may well not change from basic to applied research in response to potential license income, particularly to the extent that their work falls into Pasteur’s Quadrant. Finally, Thursby and Thursby (2001) examine a model in which faculty incentives to conduct basic and applied research change over the life cycle. In their model basic research is publishable while applied can be licensed. As the faculty approach retirement, the incentive for publishable research declines relative to applied since the faculty can collect their share of license revenue beyond retirement.

Section 3. The Data

We examine the research, demographic and disclosure profile of a group of faculty scientists and engineers at six major universities: Cornell University, MIT, University of Pennsylvania, Purdue University, Texas A&M University and University of Wisconsin - Madison. Note that our choice of universities is not random. Given our interest in the effect of licensing on faculty research, it is important to select major research universities with substantial licensing activity. As shown in Table 1, all of the universities in the sample are among the top 50 universities in terms of total research expenditures, licenses executed, and invention disclosures as reported in the 2001 AUTM Survey. All but one of the universities are above the average of the top 50.

The measure we use to reflect faculty interest in licensing is invention disclosures rather than licenses executed. While disclosures and licenses are not independent, we believe the former is more representative of faculty interest and the latter more representative of commercial quality. That is, a license disclosure is simply a document that indicates an inventor has a research result that she believes has commercial potential. While all universities in the sample require their employees file such disclosures, this is hardly enforceable. Faculty may not disclose for a variety of reasons. In some cases they may not realize the commercial potential of their ideas, but often faculty do not disclose inventions because they are unwilling to risk delaying publication in the patent and license process.[4] Faculty who specialize in basic research may not disclose because they are unwilling to spend time on the applied research and development that is often needed for businesses to be interested in licensing university inventions (see, for example, Thursby and Thursby (2002) and Jensen *et al.* (2003)). Moreover, while a disclosure clearly signals a willingness to be involved with licensing, it need not indicate that the research, itself, was motivated by the desire to license. Curiosity driven research can often lead to commercially applicable results quite by accident. Indeed, in their interviews of mechanical engineering faculty at MIT, Agrawal and Henderson (2002) found that most of them conducted their research with the primary goal of publishing results.

In order to avoid potential sample bias from the choice of faculty to include in our study we use the list of science and engineering faculty in Ph.D. granting departments of the six universities given in the 1993 NRC survey of Ph.D. granting departments. Our sample excludes any faculty not listed in such departments; for example, it excludes medical school faculty unless they also hold appointments in Ph.D. granting departments (four of the six universities have medical schools). Departments also are excluded if one could not reasonably expect disclosure activity (for example, we exclude astronomy).

The technology transfer office of each university supplied us with the names of disclosing faculty as well as dates of disclosure. Four universities provided disclosure information over the period 1983 to 1999, and the other two provided information from 1983 to 1996 and from 1987 to 1999.[5] Matching

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[4] One half of the firms in our industry survey noted that they include delay of publication clauses in at least 90% of their university contracts. The average delay is nearly 4 months, with some firms requiring as much as a year's delay.

[5] We started with 1983 so as to be well past the date of passage of the Bayh-Dole Act of 1980. Universities supplied us with data as far back as disclosure information could easily be retrieved. The 1997 end was for Purdue Univer-

these files with the NRC list provides a sample composed of multiple years of research and disclosure (or non-disclosure) activity for faculty members on the staff of our universities in 1993. We collected information on dates of hire and departure (if applicable) for each of the faculty so that the final sample only includes the faculty when they were actually at the respective universities.[6] In our sample we have 3,342 faculty and 45,889 observations where an observation consists of a person/year. The average arrival date was 1974, and few departed prior to 1999.

Thus for each faculty member in our sample, we know whether or not she disclosed (and if so, how often) in each year that she was on the faculty of her respective university during the period made available by her TTO. Of the 45,889 observations, 3,241 (7.1%) represent disclosures in a particular year by a faculty member. This is our measure of faculty *interest* in licensing activity. In the remainder of the paper, we use the term disclosure to indicate that a faculty member has disclosed at least once in a given year.

Given the publicity expressing concern that academics have become too commercial, the portion of faculty expressing interest in licensing is remarkably low. Of the 3,342 faculty, 2,145 (64.2%) never disclosed an invention, 495 (14.8%) disclosed in only one year and, and 254 (7.6%) disclosed in only two of the years they were included in the sample. Only 67 faculty (2.0%) disclosed in 8 or more of the years they were in the sample. Across the six universities, the fraction of faculty who never disclosed ranges from 53.9% to 72.2%. This, of course, does not tell us which faculty members disclosed: was it the most productive in terms of publication? More to the point, simple counts reveal nothing about changes in the nature of the research conducted by the 35.8% who disclosed.

Section 4. Disclosure Activity and Faculty Characteristics

In this section we present simple tabulations of disclosures and researcher characteristics. Given the number of observations, it is easy to detect any correlation between disclosures and other variables,

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sity. Purdue was the basis for our pilot study in this project and that pilot was initiated in 1998, hence we only collected data through 1997.

[6] For many of the faculty we could not find the arrival and departure dates. However, for some of these we were able to confirm that they were on the faculty in a given year, even if we do not know arrival or departure dates, so they did not have to be dropped from the sample.

however small that relationship might be. Thus, it is not surprising that in every case we can reject the null hypothesis that the tabulations are random.

Table 2 gives the distribution of observations and disclosures by university. For purposes of confidentiality we provide only the distribution across universities and do not identify the university (they are *not* listed alphabetically). The second column of the table (" % of Sample") gives the percentage of the sample (the percentage of the 45,889 observations) from each of the six universities. The third column is the percentage of observations from a particular university that are disclosure observations. This is the probability (stated in percentages) that an observation from some university is a disclosure observation, that is, the probability of disclosure conditional on university or Pr(Disclosure | University). The last column is the distribution of disclosures across universities. This is the probability (again, stated in percentages) that a discloser is from a particular university, that is, the probability of being from a particular university conditional on having disclosed, or Pr(University | Disclosure). For example, in the first row we know that 18.8% of the disclosures are from university 1 and that the probability of an observation from this university being a disclosure is 4.71%. Further, the probability that a disclosure observation is from university 1 is 12.72%.

Disclosure activity varies substantially across the six universities. Less than 5% of all observations from universities 1 and 5 are disclosures whereas more than 12% of university 2's observations are disclosures. An interesting question, and one we cannot answer at this point, is how this dispersion relates to university policies and culture.

As noted above, our sample includes observations over the period 1983 through 1999 and Table 3 gives the distribution of observations across years. The columns have the same interpretations as those in Table 2. The table shows a dramatic increase in disclosure activity from 1983 until the mid 1990s at which time activity leveled off with 10%-11% of a year's observations being disclosures. In 1983, the probability that a faculty member disclosed was 0.95% as compared with a probability of over 10% by 1996. Earlier we noted that only about 20% of the faculty disclose in more than one year. Here we find that, in the latter years, about one in ten faculty are disclosing in a given year. Thus, while disclosure activity has increased, it tends to be concentrated in a fairly limited number of faculty. Finally, the last column in Table 3 gives publications per faculty member for the years reported. Contrary to the notion that disclosures may come at the expense of (or show a decline in) publication, publications per faculty in our sample more than doubled. Assuming that a publication in 1983 reflects the same research productivity as it does in 1999 the increased disclosure activity may in fact reflect increased research activity. Of course, as noted earlier publication counts tell us nothing about the nature of research. If, as feared, research has become more applied, it may well be the case that applied research, in general, leads to higher numbers of publications for the same research effort.

To examine the nature of research, we map each faculty member's journal publications into Narin et al.'s (1976) classification of the 'basicness' of journals. The Narin classification scheme attempts to characterize journals by their influence on other research. While there are a number of definitions of basic and applied research, this is the only one for which there is an empirical measure. As discussed by Narin et.al (1976), basic journals are cited more by applied journals than vice versa, so that journals are more basic if they tend to be heavily cited by other journals. For example, if journal A is heavily cited by journal B, but journal B does not tend to be cited by journal A, then A is said to be a more basic journal than is B. The journals are rated on a 5-point scale. We classify as basic only those publications in the top category for basic; this rank encompasses about 62% of all ranked journals publications. Unfortunately, Narin's rating was completed in 1976 (we are not aware of a more recent rating scheme), so that new journals are not rated, and it is possible that some journals have changed their focus. While only about a third of the publications could be rated, we found no systematic change over time in the number of publications in our sample that could be rated. In a regression of the fraction of rated publications (where we drop observations with no publications, rated or otherwise) on a set of indicator variables for the year of the observation, we found an R^2 of only .0016 and very few significance differences in the coefficients of early *versus* later years.

We combine our information on annual faculty activity with information on age, year of PhD, academic field, and quality of the faculty members department. In many cases, birth dates are unavailable, in such cases we assume birth dates are 21 years prior to year of undergraduate degree, or, if date of undergraduate degree is not available we assume birth year was 29 years prior to date of Ph.D. The relation between tenure and licensing activity is an important issue, but actual data on tenure is difficult to obtain. We examine two measures. The first assumes that faculty members are tenured if they have been at their university for at least seven year. This, of course, counts as untenured many who arrive with tenure. Our second measure assumes tenure when the faculty member is nine years past the granting of the Ph.D.[7] This, of course, assumes tenure for those who fail to receive tenure at some other university, and who then "start over" at their current university. The first measure is not significantly related to disclosure activity while the second is related to disclosures. Our prior is that disclosure and tenure are related, thus we take the second measure as our preferred measure and use it in the remainder of the paper. The department quality measure is taken from the National Research Council (1995). The scholarly quality index is based on a survey; departments are rated on a 5-point scale from 0 to 5 where 5 is distinguished. Table 4 gives summary statistics for the data. The last row gives the percentage of the sample that are tenure year observations.

Tables 5 and 6 provide information on publications and the portion that are basic in relation to disclosures. Not surprisingly, those who publish more are more likely to disclose. What is somewhat surprising is that more than 34% of all disclosures were made by faculty who had no publications in the year of disclosure. Note, however, we are considering only contemporaneous publications. Nonetheless, some faculty members disclose at some point, but have zero publications for all the years they are in the sample. Those who disclose at least once in our sample account for 42.9% of all publications.

In Table 6, we dropped all faculty who did not have any publications in journals rated by Narin (1976); this leaves a sample of 12,531 observations. We then tabulated the fraction of basic publications with disclosure activity. The probability of disclosure tends to initially increase with the fraction of basic publications and then decrease. Those whose research is in the midrange (33% to 67%) have the highest probability of disclosure (14%). In the introduction we noted an interest in the behavior of basic research

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[7] We use nine years to account for post doctoral activities.

not only with respect to disclosure activity, but also with respect to time. To examine this question we continue with the reduced sample of 12,531. For this group of observations we assume that the fraction of total publications that are basic is the same as the fraction of rated publications that are basic. The number of basic publications per faculty member by year is then computed and presented in the second column of Table 7. In the third column, we present the number of total publications per faculty member by year. While these averages have varied over the 17 years, the two columns are very closely related except, possibly, for the first and last years. The simple correlation between these two columns is 0.96. The implication is that of no or little change in the relation between total publications and the percent that are basic publications.

Above we noted that we infer whether a faculty member has tenure in some year based on the length of time since the awarding of the Ph.D. In Table 8 we present the tabulation of tenure status and disclosure activity. There is a small, yet significant, relationship between tenure and disclosure activity. Faculty with tenure are more likely to disclose.

Tabulations of age and disclosure activity are in Table 9. Disclosure activity tends to rise until the middle age of 40-50 after which it declines. This pattern, of course, may reflect the fact that publications (and hence research) tend to follow that same pattern. In the last column of Table 9, we present the percentages of those in the different age categories who have at least one publication in a given year. Note that, indeed, publications first rise and then fall (after ages 40-50). There is one final point about age and our sample. Since our sample includes all faculty members in certain departments in 1993, the average age of faculty in the sample is rising. In 1983 the average faculty in our sample was 43.4 years, while in 1999 it was 55.2 years.

For each faculty member, we have information not only on age, but also on year they received their Ph.D. It is possible that there are Ph.D. "cohort" effects not captured by age. That is, while age and year of Ph.D. are highly correlated in this sample (the simple correlation is –0.87), there is likely to be independent information regarding year of Ph.D. that is not captured by age. For example, for a faculty member in the sample over the years 1983-99, age varies, but year of Ph.D. does not. If year of Ph.D. reflects to some extent the knowledge base of the researcher, and if the likelihood of disclosure is affected by the state of the field at the time of disclosure, then the cohort effect may well affect the likelihood of disclosure. This effect will not be captured entirely by age even though age and year of degree are correlated. We break the sample into the three major program areas biological sciences, engineering and physical sciences. In Table 10 we tabulate disclosure activity with Ph.D. cohorts where we use the decade of Ph.D. to classify the cohort. For each of the three major program areas those who completed their degrees in the 70's are most likely to disclose. This effect is strongest for biological sciences.

For each faculty member, we have department characteristics from the NRC survey. The characteristics of particular interest here are the major program area of the researcher and the academic quality of their department.[8]

We used the NRC's general field classification to determine whether the major program field for a faculty member was biological sciences, engineering or physical sciences. It is expected that disclosure activity will vary according to the major program field of faculty. This follows both from the nature of research (for example, engineering is more applied than physical science) and the market demand for technologies (for example, biological science results are more in demand by industry[9]). Table 11 provides a breakdown by these three program areas. We had expected that the most active area to be biological sciences. However, as is apparent from Table 11 engineering is substantially more active that biological sciences, which is in turn more active than physical sciences.

Section 5. A Logit Model of Disclosure

A weakness in what we have done thus far lies in the fact that, with few exceptions, we have looked at bivariate relationships between disclosure activity and other variables of interest. We have not considered disclosure activity relative to some variable *holding constant* the values of other variables. Here we use a probability model of disclosure wherein the probability of disclosure is modeled as a linear function of the above variables. This is purely a descriptive exercise in that we do not have a formal

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[8] Note, since many faculty are listed in multiple departments, we use the average quality across all departments listing the faculty member.
[9] According to the AUTM survey most licenses executed at universities are in the life sciences.

model of disclosure activity, nor do we account for certain potential econometric problems that a formal model might suggest needs to be accommodated.[10] Future research will consider a formal model of faculty behavior and what it implies about the proper specification of an econometric model.

In Table 12 we present the results. Disclosures are coded as ones, and results are presented as odds ratios. An odds ratio gives the effect of a unit change in a right hand side variable on the ratio of the probability of a disclosure divided by one minus the probability of a disclosure. Hence, an odds ratio of less than one implies that the right hand side variable has a *negative* effect on the probability of disclosure. After dropping observations with missing data, the number of observations is 42,243. The pseudo R^2 is 0.0756 and the chi square statistic for overall fit has a p value of less than 0.0000.

Age and a more recent year for the Ph.D. have negative effects on disclosure. For example, a 40 year old who received her degree in 1980 is less likely to disclose than a 40 year old who received his degree in 1970. However, over time, any given individual is less likely to disclose. Tenure is positively and significantly related to disclosure activity. We remind the reader that our measure of tenure is likely to be flawed. Thus, as time passes, a faculty member is less likely to disclose because she is getting older and further from the year of Ph.D. Mitigating this effect, to some degree, is the positive, discrete influence of tenure.

As publications increase, the likelihood of disclosure increases. The odds of disclosure rises by about 1% for each publication. The fraction of basic research measure used here is a positive value only if a publication can be rated and if it is placed in a journal categorized as basic. This measure of basic research is positively related to disclosure activity. Our only departmental effect, other than field, is the academic quality of the researchers department. Our data suggest that researchers in higher quality departments are more likely to disclosure. Since we are holding constant the researcher's publication rate, the departmental quality variable either suggests something about the 'quality' of the research, or else it suggests some positive spillovers from having 'high quality' colleagues.

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[10] For example, it is likely to be the case that publications and disclosure are simultaneously determined.

With regard to field of research, those in biological sciences and engineering are equally likely to disclose, all else constant, whereas both are more likely to disclose than are faculty in the physical sciences. Across the six universities there are significant differences in the probability of disclosure. In tests for the equality of university effects, the coefficients for universities 6 and 4 are not significantly different, hence they are equally likely, all else equal, to disclose. In addition, we find that the coefficients for universities 3 and 1 are not significantly different. All other comparisons are significantly different from zero. We note some rather striking differences in probabilities of disclosure across the six universities.

Regarding year effects, we find in the bivariate comparison of year and disclosure that only 0.95% of faculty disclosed in 1983 whereas over 10% disclosed by 1996. Holding constant other effects on disclosure activity we find much the same effects. Tests of equality of regression coefficients reveals that the coefficients of the 1996 through 1999 indicator variables are not significantly different from one another, but the 1997 through 1999 coefficients are significantly different from all other year effects, and the 1996 coefficient is significantly different from all prior years with the exception of 1995. Essentially, we find results in our logit regression that are similar to the results in Table 3. The probability of disclosure rises from 1983 until around 1996 when the annual disclosure rate tends to levels off.

Section 6. Concluding Remarks

A few years ago, a cover story of the *Atlantic Monthly* titled "The Kept University" questioned whether the academic enterprise as we know it has suffered with the increased financial incentives for faculty to engage in commercial activities such as licensing (Press and Washburn 2000). Despite the publicity and obvious importance of the underlying issues, we know relatively little about the relationship of such activity to faculty research, in large part because the data needed to characterize the relationship are at the level of the individual faculty member. Most of what we know comes from data provided by university technology transfer offices (either through AUTM or other research from TTO files or surveys). With this project, we attempt to reduce the gap in our understanding by building a database that allows us to examine, not only the behavior of faculty engaged in licensing, but also to compare these faculty with those who have avoided the process. In this paper, we provide a first analysis of these data.

Our analysis is preliminary and should be viewed with caution as we have avoided any formal economic and econometric modeling. Moreover, the sample represents faculty from six universities. These caveats aside, the results provide a striking picture. Note, that while the universities in our sample are above the average of the top 50 universities in terms of both research and licensing activity, we find that only a small portion of faculty engage in licensing. Indeed, 80% of the faculty in our sample either never disclosed or disclosed only once in the seventeen year period. That said, we found a dramatic increase in the portion of faculty who became involved over the period. The percent of faculty disclosing in a given year increased from 1 in 100 in 1983 to 1 in 10 by 1996, though it seems to have stabilized at for the years 1996-1999. So the much-publicized increase in licensing activity appears to be concentrated among a minority of faculty. Moreover, this increased licensing activity does not appear to signal a change in the direction of faculty research for our sample. The portion of publication that is basic by Narin's citation-based index was relatively constant over the period.

We find significant results regarding age, tenure, and year of PhD. It is not surprising that tenured faculty members are more likely to disclose (controlling for age and cohort) than non-tenured. What we find a bit surprising is that more recent PhDs are less likely to disclose (controlling for tenure and age). Recall, however, that these results are based on a purely descriptive model. Results such as this beg for a structural model that would allow us to control for other factors such as funding and university policy patterns.

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Table 1. Research & Licensing Activity in 2000

University	Total Research Expenditures	Licenses Executed	Invention Disclosures
MIT	$727,600,000	102	425
Univ. of Wisc.-Madison	$554,361,000	127	277
Univ. of PA	$529,554,951	63	223
Texas A&M	$397,268,000	58	140
Cornell	$396,900,000	63	177
Purdue	$263,440,339	76	118
Average of Top 50 Universities	$325,195,723	51	137

Table 2. University Distribution

Univ.	% of Sample	PR(Disclose|Univ)	PR(Univ|Disclose)
1	18.8	4.71	12.72
2	15.7	12.49	28.16
3	16.64	6.95	16.61
4	14.97	6.25	13.42
5	16.46	4.67	11.03
6	17.44	7.21	18.05

Table 3. Disclosure Distribution by Year

Year	% of Sample	PR(Disclose|Year)	PR(Year|Disclose)	Publications per Faculty
1983	3.98	0.95	0.54	1.62
1984	4.18	1.33	0.80	1.64
1985	4.38	1.98	1.24	1.70
1986	4.58	2.42	1.59	2.49
1987	5.87	4.62	3.89	2.36
1988	6.12	5.85	5.13	2.48
1989	6.42	5.92	5.45	2.33
1990	6.72	4.99	4.82	2.35
1991	6.91	7.33	7.27	2.42
1992	7.06	7.83	7.94	2.57
1993	7.08	8.53	8.67	2.71
1994	7.00	8.91	8.96	2.85
1995	6.74	9.22	8.93	2.92
1996	6.65	10.31	9.85	3.11
1997	5.51	11.21	8.86	3.61

1998	5.43	10.50	8.20	3.84
1999	5.37	10.17	7.84	3.69

Table 4. Summary Statistics

Variable	Mean	Std. Dev.
AGE	48.35	10.91
Year of PhD	1970.76	10.46
Quality	3.91	0.60
Publications	2.67	8.17
Tenure (%)	86.3	

Table 5. Annual Publications

Pubs	% of Sample	PR(Disclose|Pubs)	PR(Pubs|Disclose)
0	48.87	4.87	34.15
1 - 2	23.85	6.19	21.21
3 - 4	11.86	9.40	16.01
5 - 6	5.68	10.98	8.96
>6	9.73	14.08	19.67

Table 6. Percent of Basic Research

Percent	% of Sample	PR(Disclose|Basic)	PR(Basic|Disclose)
No Basic	31.19	9.72	30.67
<33	2.32	11.00	2.58
33 - 67	11.75	14.12	16.79
67 - 100	54.74	9.02	49.96

Table 7. Basic Publications by Year

Year	Basic Pubs/faculty	All Pubs/Faculty	Ratio: Column3/Column4
1983	4.96	8.04	0.617
1984	4.14	7.46	0.555
1985	4.12	7.24	0.569
1986	3.75	6.76	0.554
1987	3.74	6.57	0.569
1988	3.91	6.56	0.596
1989	3.61	6.24	0.578
1990	3.52	6.39	0.551
1991	3.35	6.11	0.548
1992	3.91	6.78	0.577
1993	3.90	6.76	0.577
1994	4.26	7.20	0.592
1995	4.32	7.50	0.576
1996	4.60	7.94	0.580
1997	5.35	8.97	0.597
1998	5.74	9.70	0.592
1999	5.29	10.07	0.525

Table 8. Tenure

Tenure?	% of Sample	PR(Disclose|Tenure)	PR(Tenure|Disclose)
No	13.7	6.44	12.24
Yes	86.3	7.13	87.76

Table 9. Age Distribution

Age	% of Sample	PR(Disclose|Age)	PR(Age|Disclose)	% With Publications
<30	3.14	5.31	2.39	33.29
30 – 40	23.99	7.01	24.14	50.09
40 – 50	31.66	8.09	36.77	54.52
50 – 60	26.19	6.30	23.69	50.97
>60	15.03	6.03	13.01	49.65

Table 10. Year of PhD

Year	% of Sample	PR(Disclose|Cohort)	PR(Cohort|Disclose)
Biological Sciences			
<1960	16.14	5.23	12.49
1960 - 1970	25.74	5.81	22.12
1970 - 1980	36.28	7.90	42.37
1980 - 1990	20.89	7.21	22.29
1990 - 1999	0.95	5.23	0.73
Engineering			
<1960	15.07	6.97	12.45
1960 - 1970	28.92	7.63	26.15
1970 - 1980	28.41	9.01	30.32
1980 - 1990	25.48	9.38	28.30
1990 - 1999	2.12	11.08	2.78
Physical Sciences			
<1960	20.28	3.06	15.83
1960 - 1970	28.90	3.32	24.44
1970 - 1980	27.89	4.31	30.64
1980 - 1990	21.76	5.15	28.57
1990 - 1999	1.18	1.72	0.52

Table 11. Distribution by Field

Area	% of Sample	PR(Disclose|Area)	PR(Area|Disclose)
Bio Sci	37.19	7.30	38.97
Eng	33.91	8.87	43.18
Phy Sci	28.90	4.30	17.86

Table 12. Logistic Model

Variable	Odds Ratio	t-Stat	
AGE	0.94	-7.89	**
TENURED	1.24	3.01	**
PUBLICATIONS	1.01	8.15	**
FRACTION BASIC RESEARCH	1.43	6.66	**
DEPARTMENT QUALITY	1.41	5.96	**
YEAR of PHD	0.96	-4.97	**
Year Indicators			
1984	1.47	1.23	
1985	2.19	2.65	**
1986	2.76	3.55	**
1987	5.61	6.51	**
1988	7.35	7.61	**
1989	7.95	7.89	**
1990	6.92	7.28	**
1991	11.19	9.19	**
1992	12.20	9.46	**
1993	14.27	9.99	**
1994	15.19	10.13	**
1995	17.76	10.61	**
1996	20.79	11.09	**
1997	24.62	11.52	**
1998	24.41	11.33	**
1999	24.03	11.12	**
Field Indicators			
ENGINEERING	1.09	1.75	
PHYICAL SCIENCES	0.48	-12.59	**
University Indicators			
UNIV-2	1.95	6.23	**
UNIV-3	1.02	0.24	
UNIV-4	1.38	4.02	**
UNIV-5	0.79	-2.46	*
UNIV-6	1.36	3.62	**

** Significant at 1% level
* Significant at 5% level