Organizational Structure as a Determinant of Academic Patent and Licensing Behavior: A Survey of American Research Universities

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Abstract: This study examines the influences of university organizational structure on technology transfer performance. The analysis treats the organizational structure of the technology-transfer office as an independent variable that accounts, in part, for measured differences in inter-institutional patenting, licensing, and sponsored research activities. We derive and investigate hypotheses that link attributes of organizational form – information processing capacity, coordination capability and incentive alignment – to technology transfer outcomes. A detailed analysis of survey data from American major research universities provides evidence of the existence of alternative organizational structures. The data also suggest that these organizational capabilities result in differences in technology transfer activity.

1. Introduction

While private firms are the engines of innovation in the economy, universities provide basic fuel in the form of ideas and knowledge. Universities are key institutions in the national innovation system and places where basic understandings of complex phenomenon are advanced and scientific discoveries, some with the potential to transform existing industries and create new industries, are made. Over the past fifty years we have seen that the knowledge content required to innovate has increased, indicating that the transfer of knowledge from universities to industry is more important across the economic spectrum. New industries, such as biotechnology, advanced optics and photonics and material science have arisen, built largely on knowledge advances pioneered by academic researchers.

We need to acknowledge that perhaps a university's greatest contribution to economic growth and technological change is embodied in its graduates. However, there are ideas that are captured as intellectual property. These ideas become inventions and are the property of universities in the United States as set forward in the Bayh-Dole Act of 1980. Universities have a social responsibility, a reputational stake, and, at times, an economic incentive to pursue the commercialization of these ideas. Of course, universities are not commercial entities and so it is incumbent upon universities to license their intellectual property to firms, both small and large, to ensure that academic findings are brought to the market as a means for to public benefit realization. This is the formal process of technology licensing and commercialization.

The unresolved question is how to best ensure that university ideas are efficiently and effectively commercialized. While some many question the legitimacy of this undertaking our point is departure is the fact that universities are actively pursuing technology transfer activities. Every public and private university in the United States and even some 4-year colleges and 2-year institutions has experimented with technology transfer. Still questions remain about what is the best way to manage technology transfer activities in order to realize a social and economic return on the significant investment of public funds in university research.

The ability of a university to transfer technology to external actors is increasingly considered an important metric of university engagement and relevance. Over the past thirty years, American universities have invested significant resources in formal technology transfer activities, organizing technology transfer offices that manage the process of engaging faculty to report inventions, applying for intellectual property protection and negotiating with firms to sponsor research and license university discoveries. Evidence suggests that the efficiency of academic patenting, licensing, and spinout generation is a function of the office characteristics. This study adds to the emerging literature by considering how organizational structure mediates the relationship between inputs that give rise to intellectual property and the level and forms by which the university disseminates and generates revenues from this intellectual property.

Our results, based on data gathered from a survey of university technology managers and matched with data from the Association of University Technology Managers (AUTM), indicate that technology transfer activities -- invention disclosures and licenses, are shaped by the resources, reporting relationships, autonomy, stability, and incentives of technology transfer offices. Our analysis treats the structure of the technology transfer office as an independent variable that accounts, in part, for measured inter-institutional differences in patenting, licensing, and sponsored research activities.

This analytical lens permits a sharpened focus for examining variations that others have alluded to in caveats or qualifying statements but has not systematically studied.

In this report, we focus on the technology transfer operations at 90 American Research Universities that participated in the 2007 Association of University Technology Mangers (AUTM) Licensing Survey. We begin by describing our survey methodology. We then present descriptive statistics and are able to examine office characteristics. There is substantial variation among the offices in their organization and strategies towards technology licensing. This organizational variation translates back to technology transfer outcomes. Rather than considering best practices, our findings are based on regressions that reveal some systematic evidence about what types of offices are able to engage in reoccurring relationships with industry and achieve better technology licensing outcomes. This report concludes with suggestions for future research.

2. Data

In order to understand variation in university technology transfer organization, we conducted a survey of the Association of University Technology Managers (AUTM) members. The survey was pretested and designed to insure reliability and construct validity. The survey's eighty-four questions focused on five topics:

1. Technology Transfer structure of the University, including reporting relationship to other offices at the university.
2. Office Resources: Office expenditures, Professional staff qualifications and tenure, Professional vacancies - including recruiting strategies, employment of students.
3. Office Organization, location, satellite offices, foundations.
4. Industrial Relationships – Are companies encouraged to both license and sponsor university research, evaluating the availability of funding in the form of university seed fund/venture fund, private equity funds, gap or maturation fund.
5. Technology Transfer Policy: Revenue distribution formula scales and changes, responsibility for material transfer agreements, use of equity agreements, spinout companies - focusing on the institutional policies/practices for university spinouts, and licensing.
6. External resources: state initiatives that affect technology transfer.

Our sampling frame was a mailing list provided by the Association of University Technology Managers (AUTM) for their Annual Licensing Survey. Surveys were sent to 393 universities and research institutions across 29 countries. After 4 months (July-October 2008) of collecting data, we received 196 responses, a 50% response rate.

For the analyses presented here we focus solely on the U.S. university respondents. U.S. universities and research institutions accounted for 261 of the questionnaires mailed and 142 of the responses received (an effective response rate of 54% for this subset). Of these 142 respondents, 120 were universities and the remainder was medical centers and research institutes. However, outcome data on disclosures, patents, and licenses from the AUTM 2007 licensing survey or the institutions website was available for only 90 of these respondents. Twenty-two of our respondents were private universities (24.4%) while 68 (75.6%) were public institutions.

The sample appears to be representative of the population of AUTM survey respondents: there is no statistically significant difference between our respondent and the entire AUTM population for average annual research expenditures and for the average of the technology transfers outcomes. From our analysis we note that universities who do not participate in the AUTM Annual Licensing Survey are, on average, smaller in terms of office expenditures and number of Full Time Equivalent employees (FTEs), are also younger and have smaller annual research expenditures.

Table 1 in the Appendix presents correlation for the main variables of interest in our model. There is some evidence of multicolinearity among the independent variables. Universities with large research budgets spend more on technology transfer and establish offices earlier. Office expenditures reflect the number of FTEs working in the office.

3. Heterogeneity in Organization and Technology Transfer Outcomes

Among our respondents, life sciences are the most licensed technology. Fifty-eight of the respondents (85%) reported some licensing activity in the life sciences, ranging from 10% to 100% of their total activity. The mean percentage was 52.5% and median was 50%. For the 38 universities with medical schools, 6 focused 100% of their licensing activity in the life sciences (mean = 65.1%; median = 72.5%). Interestingly, universities without medical schools reported that licensing in the life sciences (mean=36.9%; Median = 30.0%; Max = 100%).

Material science discoveries accounted for 11.9% of the universities' licenses (mean = 11.9%; median = 5.0%). Forty-two of the universities reported some licensing of material science discoveries: the range was from 3% to 100%. Software was licensed by 44 of the 66 reporting universities (67%). The range was from 1% to 65% (mean=

9.3; median = 5.0%). Electronic inventions were licensed by 36 of the universities (mean = 7.5%; median =4.0%; max= 70.0%). Chemical inventions were reported as licensed by 29 of the 66 universities (mean = 4.0%; median = 5.9%; maximum = 34.0%).

The survey included a residual category for licenses outside of the technologies provided. The residual category of "other" was mentioned 14 times, accounting for a mean of 5.4% of the licensing activity (median = 0.0%; maximum = 100%). Engineering licensing was mentioned by 11 of the 66 universities (mean = 9.3%; median = 5.0%; maximum = 65.0%) as a write-in response to the category other. Three universities explicitly mentioned educational products (max = 14.0%).

Universities differ greatly in their academic footprint and thus in underlying innovation capacity. First, there is great heterogeneity with regards to the presence of academic programs, such as medical schools, engineering schools, and law schools. Twenty-eight (31.1%) of our sample institutions have all three programs while 9 universities (10%) do not have any of these academic programs. Medical and engineering schools are believed to be the most relevant for technology transfer activity. Forty universities (44.4%) in our sample have both engineering and medical schools while 26 (28.9%) have an engineering school without a medical school and 14 (15.6%) have a medical school but no engineering school. Conversely, 7 (7.8%) universities have law schools without either a medical school or engineering school

We expect greater technology transfer activity from universities that realize the synergies from the presence of all 3 academic programs. Broadly, having both a solid technology base (due to the medical and engineering schools) and access to on-campus legal resources (via both students and faculty in the law school) provides a diversified, yet complementary, foundation for commercialization pursuits. Irrespective of laws school resources, greater technology transfer activity is also expected to be associated to the presence of both medical and engineering schools. Activities in multiple scientific disciplines that are of interest to a greater number of industries and industry players increase transfer opportunities.

Focus on Start-ups

Twenty- eight percent of the technology licensing offices report that they do not have responsibility for developing spinout companies (20 out of 71 universities with valid answer to question). About half of the reporting universities reported institutional policies and practices that favor locating university spinouts locally.

The survey asked tech transfer offices what services they provided to start-up companies. Sixty percent reported making introductions to venture capital firms. One-third reported providing assistance with writing business plans while another 28% reporting partnering with their university business school to provide business plan assistance. Sixteen percent reported providing start-ups with assistance recruiting and hiring employees. Another need of start-ups is incubator space and 30% reported helping companies locate space in a university incubator or elsewhere.

Financing is a perennial limitation for start-up firms. Eleven respondents (15%; 74 valid responses) reported that their university currently has a seed fund/venture fund to invest in university spinouts. The technology licensing office managed the majority of these funds (10 or 91%). One fund was managed by an external independent organization. Another 20 universities report they have plans for a seed fund in the future. The survey asked if the office regularly worked with private equity funds to invest in university spinouts. The majority of offices (53.4%) report continuing relationships with private equity firms. We asked if the equity firms were local: responses varied from 100% were local to 0, reflecting characteristics of the local area. Universities that supported an internal seed fund to invest in university spinouts also had continuing relationships with external private equity firms, suggesting that these financing mechanisms are complements and not substitutes.

4. Heterogeneity in Effort

Fifty-nine universities reported total office expenditures for the 2007 fiscal year. The maximum dollar amount was $23 million dollars. The mean dollar amount was $3 million while the median was $1.7 million. The minimum was $200,000. In general, technology transfer office expenditures were statistically significantly correlated with university research expenditures (Pearson correlation coefficient = 0.58). Private universities were slightly more likely to have higher expenditures for their technology transfer offices (Pearson Correlation Coefficient = 0.26).

Within our respondents, the first technology transfer office was established in 1925, with 15 offices established before the 1980 passage of the Bayh-Dole Act. The

Bayh-Dole Act is considered a watershed event in formal university technology transfer. The most recent office was initiated in 2006, the year before our survey. The mean starting date was 1987, with a median of 1989. Ten offices began in 1985, the mode for our distribution.

The age of the technology transfer office is positively correlated with university total research expenditures (Pearson correlation coefficient = 0.473) and the number of professionals working in the office (Pearson correlation coefficient = 0.42)[1]. Having a medical school or engineering school was not highly correlated with office age (Pearson correlation coefficient between office age and presence of a medical school = -0.07; Pearson correlation coefficient between office age and the presence of an engineering school = -0.05).

The size of technology transfer offices in our sample ranges from 0 to 77 full time equivalent professional employees (FTEs), with a mean of 6.4 and a median of 4. The distribution is highly skewed. Over ninety percent of the offices have 10 or fewer professional staff. Eight offices (9%) report only 1 professional FTE and 16 offices (18%) report 2 professional FTE. Thirty seven percent (37%) of the offices have at least one professional vacancy and our respondents reported that it takes 4 months on average to fill a professional vacancy. When facing a vacancy, the offices throw the net wide -- 81% of the offices recruit nationally.

The directors of the technology transfer offices generally hold advanced degrees. Forty percent of directors hold a PhD degree; 19% of office directors are lawyers and an additional 18% have a Masters in Business degree. The remaining 20% of the directors have bachelor's degrees. On average, directors are in place for a mean of 7.7 years (median 5.6 years). The maximum tenure for a director in our sample is 27 years. Directors report they spend the largest amount of their time marketing technologies to, and building relationships with, companies (mean percentage of time = 22.2%), followed by working with faculty to get invention disclosures and negotiating licensing agreements.

Employment in a technology transfer office appears to open the door for career mobility and career advancement. Of the staff that leaves, on average, about 50% go to other university technology licensing offices, 22% go on to private licensing operations,

[1] The correlation between office expenditures and the number of tech transfer professionals was 0.53.

and another 22% leave with spin-off companies. Six percent are promoted to other positions within the university. Since one of the important roles of universities is training, the idea that technology licensing office experience prepares individuals for private sector employment warrants further study.

Universities employ students in their offices to augment their capabilities and provide practical learning experience for students. Sixty percent of the offices in our sample reported employing both undergraduate and graduate students. An additional 26% employed only undergraduate students, while 13% employed undergraduate students alone. Most of the offices (80%) employed students from diverse backgrounds Overall science students (graduate student: mean = 40.0%; median = 33.5%; undergraduate: mean = 24.1%; median = 22.5%) were the most common discipline group employed. Though at a lower rate, students from professional programs in Law and Business were also employed. The two professional groups were tapped in equal percentages (mean = 23%).

The students were involved in a variety of activities in the technology transfer office. Most commonly, students contributed by conducting marketing research (83%), followed by preliminary patent analysis, prior art searches or drafting of patents (70.7%). Undergraduates are often used to manage office communications (27.6%) and to provide clerical or administrative support (69%).

Material transfer agreements (MTAs) are contentious because they are considered time consuming while offering little upside revenue potential.[2] Sixteen percent of the offices do not handle MTAs. Two-thirds of the offices are responsible for executing both incoming and outgoing agreements. An additional 19% of the offices are responsible for negotiating outgoing MTAs while the researcher who invented the materials negotiates incoming MTAs.

Policies towards licensing revenue distributions are either fixed over all revenue ranges (70%) or decrease the inventor's share with an increase in the total amount of revenue received. The average inventor's share is 40% (both mean and median), with a range from 20% to 55%. One university reported that inventors receive 100% of all profit directly to the inventors up to $10,000, with a 50/50 split for additional profits to

[2] The survey respondents reported that 10% of their time was spent negotiating MTAs and other agreements.

$200,000 and a 75/25 split for larger amounts. In an interview, the office reports that they are trying to motivate faculty to participate in technology transfer. Thirty percent of the offices (25/83 reporting on this question) are able to negotiate exceptions to the revenue distribution formula with individual faculty members.

5. Day-to-Day Priorities for the Office

Technology transfer offices vary greatly with respect to their authority and responsibilities. While all except one of the universities negotiates equity-based licensing agreements for their university, 17% (14 respondents) state that their offices do not have the authority to execute these agreements. Two-thirds of the respondents have signature authority for licenses and option agreements. The other third must secure agreement from another office, requiring greater time and entailing greater uncertainty. One-third of the offices engage in end-user licensing of software or other copyrighted materials. Ninety percent of the offices have signature authority for non-disclosure agreements.

The survey asked about the objectives that best characterized the day-to-day priorities of the office. Respondents were given a list of options and asked to rank each option using a Likert scale with 5 as a very import objective and 1 as not important. Service to the faculty received a rating of 5 by 78.5% of the respondents. Revenue generation from licensing was ranked as very important by 32.9% of the technology transfer offices. Economic development was listed as very important by 15.6% of the respondents. Responses did not vary among public/private universities. Technology transfer offices at Universities with medical schools were more likely to rate service to the faculty as very important and less likely to rate revenue generation as highly.

The survey asked the respondents how they spent their time. The distribution was that 60% of their monthly hours were spent equally divided on working with faculty, marketing technologies to companies and negotiating licensing agreements. Internal administrative duties accounted for 15% of the respondents' time. 10% of their time was spent negotiating MTA and other agreements. The remaining 5% of time was spent on economic development activity.

The survey also asked the respondents to rate the university's contribution to local economic development. Spinning out local companies received the highest rating (median = 4), followed by the efforts of students and faculty working or volunteering with the local community (median = 3). Based on the example of President Judith Rodin's strategy at the University of Pennsylvania to invest in the local community, the survey question asked about other types of real estate investment and community outreach, which were not considered significant by the respondents.

The survey asked respondents the extent to which, given their present role in the technology transfer office, they agreed with the following four statements (On a scale of 1 = Do not agree to 5=Completely agree):

1) My university, in addition to its basic functions of teaching and research, should be actively and directly involved in assisting state and regional economic development (mode = 5; median = 4; mean = 3.7; s.d. = 1.2)
2) My university should encourage and reward faculty to engage in user-oriented, proprietary research with industry funding (mode = 4; median = 4; mean = 3.6; s.d. = 1.2).
3) My university should reward faculty who produce a patentable invention at least the same amount of credit as a peer reviewed article when making tenure and promotion decisions (mode = 5; median = 4; mean = 3.7; s.d. = 1.4)
4) Knowledge creation is best measured by scholarly, peer review publications (mode = 3; median = 3; mean = 3.2; s.d. = 1.2).

Three quarters of the respondents report that their offices participate in state economic development initiatives. More than half of the offices report they have worked with state officials to help recruit out of state companies to their local region.

Most of the offices are located on campus (72%) while the remaining 28% are located off-campus. Most of the off-campus offices report that they are less than one mile from campus. The maximum distance was 15 miles with an office that was located in a university affiliated technology park. The literature would suggest that an on campus office would be more accessible for faculty, however our interviews reveal that an off-campus technology transfer office may benefit from easier accessibility and parking for their business clients.

Fifteen universities (20%) report having satellite technology transfer offices located within specific colleges and schools of the university. In most cases (80%) the university technology transfer office had administrative control over the satellite office. In other cases, there was a dual reporting relationship with the dean or administrative unit where the satellite was located.

6. The Influence of Office Characteristics on Technology Transfer Outcomes

Invention reports or disclosures are an output measure that indicates faculty participation in technology transfer and represents the initial measure of the number of inventions that the offices have available to patent or license. Data for disclosures are available for all 90 universities in our focal sample.

The mean number of annual disclosures was 130.5 (median = 83.5; minimum = 4; maximum = 1411). The cumulative number of disclosures was available for 76 universities. For cumulative disclosures, the mean was 404 (median = 293; minimum = 13 and maximum = 4023). The number of disclosures, both annual and cumulative, are correlated with research expenditures (Pearson correlation coefficient (annual) =0.97; Pearson correlation coefficient (cumulative) = 0.95); office expenditures (Pearson correlation coefficient (annual) =0.48; Pearson correlation coefficient (cumulative) = 0.50); number of professional office staff (Pearson correlation coefficient (annual) =0.92); and, office age (Pearson correlation coefficient (annual) =0.33; Pearson correlation coefficient (cumulative) = 0.26). These results are as expected and not surprising. The presence of a medical school or engineering school is not significantly correlated with disclosures, nor is the type of institution (public/private).

We start with a base regression model for disclosures, and then add in other variables of interest to the committee. The base model results control for university resources and capacity. The results are as expected: disclosures increase with the number of technology licensing office professional FTEs and the dollar amount of total office expenditures and total university research expenditures.

Next, we tested for the office directors' experience on the job. Previous interviewees raised high turnover as a concern for many technology transfer offices. While there have been advances in the information technology infrastructure of the offices, there is a great deal of experiential knowledge of the university landscape and the transfer process that remains tacit. Directors, who have learned by doing over their tenure, are key repositories of such information and further have established relationships that make them effective in their jobs. As such, one would expect that office performance would reflect leadership stability. Our results support this contention (see table 3). We find that the amount of time the director of the office has been in their current position increases the flow of disclosures.

Conversely, the frequent change in directors (measured as age of the technology licensing office divided by the number of directors during this period) is a net drag on the number of disclosures. Beyond the loss of tacit knowledge, turnover disrupts organizational routines which can also reduce performance (see table 4). Our interviews revealed that many times offices are reorganized when the university administration changes, disrupting office efforts.

Patents are the next logical outcome in the technology transfer process and data are provided for the number of patents granted to the university along with the annual new patent applications in 2007. The mean number of 2007 patents granted was 26.3 (median = 18.5). The underlying distribution is highly skewed, the minimum is 0, the maximum is 331 and the standard deviation is 42.0. Similarly, the number of annual patent applications ranges from 0 to 959, with a mean of 82 and standard deviation of 124. The number of patents, both applications and granted, are correlated with research expenditures (Pearson correlation coefficient (granted) =0.94; Pearson correlation coefficient (applied) = 0.91); office expenditures (Pearson correlation coefficient (applications) =0.42; Pearson correlation coefficient (granted) = 0.55); number of professional office staff (Pearson correlation coefficient (applications) =0.82; Pearson correlation coefficient (granted) = 0.91); and, office age (Pearson correlation coefficient (granted) =0.41; Pearson correlation coefficient (applied) = 0.26). The presence of a medical school or engineering school is not significantly correlated with patents, nor is the type of institution (public/private). Interestingly, the presence of a law school is correlated with both patent outcomes (Pearson correlation coefficient (granted) =0.24; Pearson correlation coefficient (applied) = 0.23).

Licenses and licensing income receives a great deal of attention as outcomes of technology transfer. After all, business willingness to engage in a monetary transaction for a university technology is a market test of the utility of that technology, however there are many other considerations that determine the amount of licensing revenue received. In 2007, 86 universities reported that they initiated an average of 31 new licensing agreements (median = 21.5; minimum =0; maximum = 231; standard deviation of 34.9). Licensing income in 2007 averaged $12 million (median = $1.8m; standard deviation p $25 million; range = $6,000 to $136 million). The skewed distribution of licensing receipts is well known.

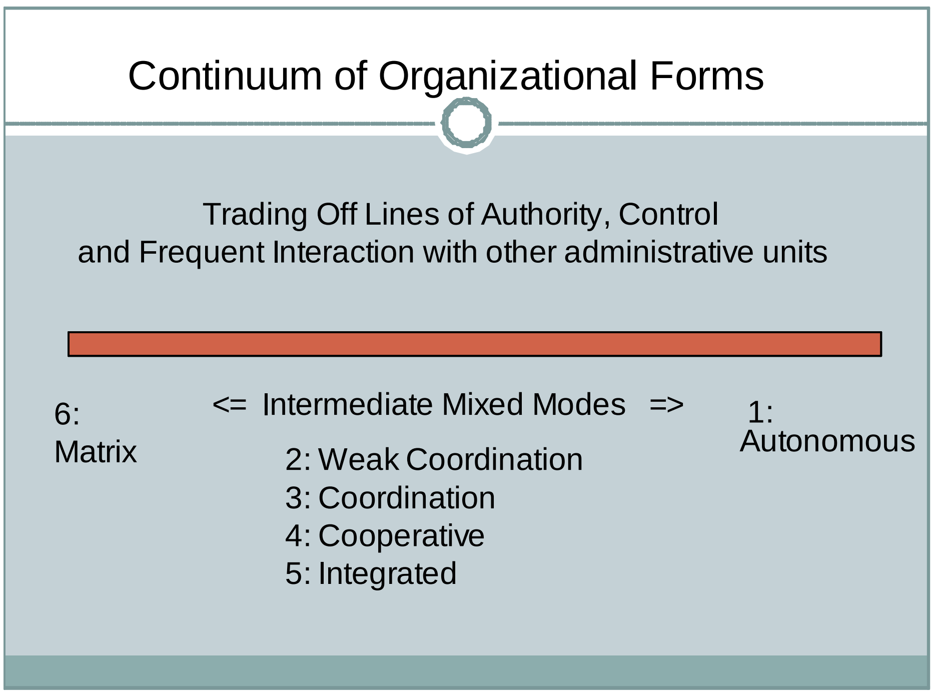
The number of licenses and the dollar amount of licensing revenue is less amenable to econometric modeling. The number of disclosures is included as the raw material available for licensing and this underlying relationship holds: more disclosures yield more licenses an greater income. Neither office size or office age was found to be significant predictors of licensing activity. Likewise, having a medical school did not appear to engender a greater number of licenses. Adding in director's experience to this base model does not improve performance. However, we do find that both research expenditures and office expenditures are positively related to licensing outcomes, after controlling for raw materials – the number of invention reports or disclosures.

The dollar amount of licensing income is also correlated with the availability of resources. Licensing income is positively correlated with university research expenditures (Pearson correlation coefficient = 0.55); tech transfer office expenditures (Pearson correlation coefficient = 0.52); and, number of FTE (0.65). Institutional characteristics are also correlated with licensing income: private universities (Pearson correlation coefficient = 0.373), and office age (Pearson correlation coefficient = 0.366).

Start-up companies are considered important for economic development and job creation. Eighty-two universities reported data on start-up firms in 2007. Fourteen universities (17.1%) did not report any start-up activity in 2007. The maximum number of start-ups was 38, while 21.1 % (19 universities) reported a single start-up in 2007. The mean number of start-ups was 4, while the median was 2 (standard deviation = 5). One again, university research expenditure have a strong positive effect on this outcome (Pearson correlation coefficient = 0.84). Office expenditures (Pearson correlation coefficient =0.46) and office age (Pearson correlation coefficient = 0.29) are positively associated with the number of start-ups. The number of FTE in the office appears to have a negative effect on the number of start-ups (Pearson correlation coefficient = -0.26). A division of labor in larger offices that favors the hiring of licensing specialists – a prediction that warrants further investigation, might explain this. The presence of a university law school is positively associated with the number of start-ups (Pearson correlation coefficient = 0.32). Twenty- eight percent of the technology transfer offices report that they do not have responsibility for developing spinout companies (20 out of 71 universities with a valid answer).

7. Technology Licensing Office Strategies

The survey asked a range of questions about reporting relationships within the university. Two-thirds of the respondents report to the Office of the Vice President for Research (59 out of 90). Fourteen percent report directly to the Office of the President/Provost or Chancellor (13 out of 90). Nine offices (10%) have multiple reporting responsibilities within the university. The remaining 9 offices (10%) report to the Office of the Vice President for Economic Development/Business Development or a title that reflected a similar orientation.



The survey asked a range of questions about how the technology transfer office was situated within the organization. The survey considered collaborations and information sharing with 9 offices in the university. The most relevant internal university offices that the technology transfer office collaborated with are sponsored research, industrial liaison or research office, and the economic development office. Offices varied in the degree and extent of collaboration, sharing of contacts, the degree of signature authority for the office and the degree to which the same companies both licenses and sponsor research. Technology transfer offices have significant variations in links with the other key boundary-spanning functions/offices at the university as shown below for the 78 respondents providing complete information for this set of questions.

Table 8: Relationships with the office of sponsor research

	Reporting Relationship	#	%
1	Completely separate and Autonomous	28	35.9%
2	Administratively separate/common reporting requirements	38	48.7%
3	One university-wide office under common administrator	12	15.4%

Table 9: Relationships with the office of industrial relations

	Reporting Relationship	#	%
1	Completely separate and Autonomous	43	55.1%
2	Administratively separate/common reporting requirements	13	16.7%
3	One university-wide office under common administrator	22	28.2%

All of these attributes may be synthesized to 6 different organizational forms that range from technology transfer offices that are completely separate and autonomous, with limited coordination and interaction with other internal offices to the opposite extreme of technology transfer offices that are fully integrated with research administration and industrial outreach, have frequent contacts with other offices, and get licensing leads from other departments and divisions within the university. These 2 organizational caricatures bracket a continuum of office forms, with 4 additional categories represented. We created a composite measure of organizational form that combines the above data to simultaneously consider the technology licensing office's links to sponsored research and industrial relations. The forms are listed by degree of integration.

Table 10:

TLO-SR Tie	TLO-IR Tie	Composite Form	#	%	Org Type
1	1	Autonomous	19	24.3%	1
1	2	Weak Coordination	19	24.3%	2
2	1				
2	2	Coordinated	13	16.7%	3
1	3	Cooperative	13	16.7%	4
3	1				
2	3	Highly Integrated	7	9.0%	5
3	2				

3	3	Matrix	7	9.0%	6

Regression results indicate that the technology transfer outcomes of the number of disclosures and licenses increase when the technology licensing office is more integrated with other operations at the university.[3] Licensing revenue did not appear to be associated with organizational form – a result that is congruent with the idea that licensing revenue is a rare event subject to luck. Similarly, the number of start-up firms was not related to variation in organizational form, suggesting that other factors such as the amount of start-up support both internal and in the external ecosystem may be more important.

We found that organizational form (coded via the table above – Higher values indicating that the technology licensing office was more integrated within the university and had greater ability to leverage resources within the university) was a significant predictor the intensity of industry relationships. The data confirm that the different functions – licensing, sponsored research, and industrial relations, are more likely to share information about the firms that they deal with as well as more likely to coordinate their efforts when the functions are more tightly linked (or integrated) via office structure. As shown in Table 11 below, frequency of interaction between functions increased as office integration increased. (The interaction variable was reverse coded (1=daily to 4=never) so a negative coefficient on the form independent variable in the tables below indicates greater interaction).

This greater information sharing is key to the recognition and pursuit of opportunities that can generate re-occurring, multifaceted relationships between the university and key industry players. Given that long-term, reoccurring, multifaceted relationships with industry appear to increase licensing activity this argues that a less autonomous office organization with frequent interaction with other offices in the university will increase licensing outcomes. We also found a positive relationship between self-sufficiency (in terms of the share of office expenditures covered through cost recovery and licensing income) and the intensity of industry relationships. The

[3] These results are robust to various econometric specifications, controlling for office age, research expenditures, number of FTEs, the presence of a medical school, director education and experience, and type of institution (public/private; AAU).

ordered Probit (DV=Intensity of Industry Relationships) analysis is shown in the table 12 in the Appendix.

8. Reflective Conclusions and Future Research

Technology transfer is still a new function at the majority of universities. Universities with the oldest offices perform best in terms of generating disclosures and licenses. Other universities are still defining their technology-licensing function. Often there is active faculty resistance to participating in formal technology licensing or inflated expectations about the possible fortunes to be made by faculty from their ideas. There is evidence that similar resistance to a new university function was present when sponsored research was first introduced (Servos 1996). While academics now accept the sponsored research function, technology licensing is still in its emerging phase. The results suggest that organizational form matters for the performance of the technology licensing office. The question to address is the optimal organizational form to best satisfy university, inventor and societal objectives. The current period may be characterized as a period of experimentation and learning.

Indeed, this report finds that offices are very differently organized within their university hierarchy. Of course, one of the strengths of the American system of higher education is the diversity of institutions, both public and private, and their competition for resources. Our findings suggest that universities across the institutional spectrum are engaged in technology licensing. A most interesting and unaddressed question is how institutional variation interacts with local characteristics and influences the impact of university technology licensing. Our results reveal that some university technology licensing offices accord great attention to start-up firm formation while others do not have responsibility for this activity. This suggests that universities may be adopting their focus to what the local environment can sustain. Our interviews reveal that some universities are focusing of licensing to large firms regardless of location while other offices emphasize local start-up activity.

Among our respondents 85% reported licensing activity in the life sciences, which is also the dominant licensing activity at those universities. In general, universities that have medical and engineering schools simply have greater capacity to generate ideas that could be transferred to industry. Yet the absence of these programs did not hinder university activity in technology licensing. The combination of a medical school, engineering school and law school, controlling for research expenditures, creates synergies that influence technology licensing. Our analysis did not examine the presence of business schools or entrepreneurship programs, which often have emphasize intellectual property management and new firm formation. Including the university presence of a business school would be a worthwhile extension. The recent release of the National Research Council's rating of academic departments would be another extension. While the conventional wisdom emphasizes the top universities our interviews suggest that highly ranked programs at any university can be a source of technology licensing.

Universities technology licensing offices differ in the amount of resources available to them. The few offices that were established prior to the passage of the Bayh-Dole Act are among the most successful operations. We find that the passage of the Bayh-Dole Act, which required universities to account for and manage inventions from federally funded research, spurred the creation of technology licensing offices. The median start date for our distribution was 1989, indicating that offices are, on average, about twenty years old. The age of the office is a positively correlated with total university research expenditures.

We looked at those offices with 4 or fewer employees (the median FTE was 4). The analysis is somewhat tautological: because the offices are small, they are less well-funded and represent universities with small research expenditures and do less well generating licenses and disclosures. The set of universities with 4 or fewer employees appear to have attitudes that were pro-technology transfer when compared to their larger counterparts. Small universities had higher agreement with the following statements: "My university should encourage and reward faculty to engage in user-oriented, proprietary research with industry funding." and "My university should reward faculty who produce a patentable invention at least the same amount of credit as a peer reviewed article when making tenure and promotion decisions." The special situation of the smaller office would be an interesting area for further research.

This report and the survey are a first attempt to understand the day-to-day operations of the university technology licensing offices. We find that while the majority of the respondents have signature authority for licenses and option agreements, a third of university offices must secure agreement from another office – creating an obstacle for their operations. In addition, one-third of the offices are actively engaged in end-user licensing of software or other copyrighted materials.

We find that office characteristics influence outcomes. All outcomes – invention disclosures, number of licenses and licensing income -- increase with more resources, including the dollar amount of office expenditures, the number of office staff and the amount of research conducted by the university. We also find that outcomes increase when office directors have spent more time in their position and when there are less office reorganizations. Simply put, technology licensing is about relationships. More stable offices with consistent leadership are able to establish working relationships with faculty to increase the flow of invention reports and with companies to increase the amount of licensing activity.

Finally, we examine technology licensing office strategies at the different universities as reflected by the reporting relationships within the university and the degree of autonomy provided for the office. We find evidence of 6 different organizational forms that are systematically related to the extent to which the office is able to form relationships with their industrial partners rather than engaging in simple one-off transactions. The results suggest that offices that are highly integrated with other functions at the university and report to one university administrator were most effective.

The usual academic disclaimers apply. This study is exploratory and aims to illuminate some of the underlying causes for the observed differential performance of university technology licensing offices, which are sometimes criticized without recognition of the great heterogeneity in office resources and capabilities. While we always hope for more observations and greater response rates this study suggests that the organization of technology licensing offices is salient to the discussion of technology licensing.

Table 1: Correlations among various University Tech Transfer Outcomes

		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
Cumulative Licensing Income (a)	Pearson Correlation	1.000	.718**	.459**	.454**	.452**	.506**	.526**	.500**	.485**	.460**	.470**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	N	71	71	71	69	71	69	71	71	71	70	70
2007 License Income (b)	Pearson Correlation	.718**	1.000	.551**	.524**	.564**	.736**	.633**	.615**	.569**	.593**	.610**
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000
	N	71	82	82	69	82	79	81	82	71	81	81
2007 Research Expenditures (c)	Pearson Correlation	.459**	.551**	1.000	.987**	.832**	.869**	.838**	.966**	.967**	.936**	.906**
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000
	N	71	82	83	70	83	80	82	83	72	82	82
Cumulative Research Expenditures (d)	Pearson Correlation	.454**	.524**	.987**	1.000	.827**	.886**	.814**	.946**	.953**	.916**	.903**
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000
	N	69	69	70	70	70	68	70	70	70	69	69
2007 Licenses (e)	Pearson Correlation	.452**	.564**	.832**	.827**	1.000	.900**	.733**	.840**	.826**	.804**	.755**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000
	N	71	82	83	70	86	80	82	86	72	85	85
Cumulative Licenses (f)	Pearson Correlation	.506**	.736**	.869**	.886**	.900**	1.000	.760**	.892**	.906**	.892**	.824**
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000
	N	69	79	80	68	80	80	79	80	70	79	80
2007 Start-ups (g)	Pearson Correlation	.526**	.633**	.838**	.814**	.733**	.760**	1.000	.879**	.882**	.857**	.834**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000
	N	71	81	82	70	82	79	82	82	72	81	81
2007 Invention Disclosures (h)	Pearson Correlation	.500**	.615**	.966**	.946**	.840**	.892**	.879**	1.000	.981**	.962**	.939**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000
	N	71	82	83	70	86	80	82	90	76	86	85
Cumulative Invention Disclosures (i)	Pearson Correlation	.485**	.569**	.967**	.953**	.826**	.906**	.882**	.981**	1.000	.967**	.954**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000
	N	71	71	72	70	72	70	72	76	76	72	71
2007 Patents Granted (j)	Pearson Correlation	.460**	.593**	.936**	.916**	.804**	.892**	.857**	.962**	.967**	1.000	.890**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000
	N	70	81	82	69	85	79	81	86	72	86	84
2007 New	Pearson Correlation	.470**	.610**	.906**	.903**	.755**	.824**	.834**	.939**	.954**	.890**	1.000

	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	
	N	70	81	82	69	85	80	81	85	71	84	85

**. Correlation is significant at the 0.01 level (2-tailed)

Table 2: Basic Model

Disclosures	Coefficient	Std. Error	Level of Significance
TLO Professional FTEs	7.78	2.12	***
Medical School	-16.25	17.03	
Log of TLO age	-9.23	18.26	
Log of Research Expenditures	53.05	12.21	***
Log of Total Office Expenditure	16.69	9.82	*
Constant	-1141.44	216.81	***

N = 52

Table 3: Director's Experience at the University

Disclosures	Coefficient.	Std. Error	
TLO Professional FTEs	14.84	3.12	***
Medical School	-12.96	16.19	
Log of TLO age	-6.26	17.05	
Log of Research Expenditures	42.34	11.77	***
Log of Total Office Expenditure	5.92	9.40	
Directors Tenure	21.68	7.78	***
Constant	-870.45	225.77	***

N = 46

Table 4: Director's Turnover

Disclosures	Coefficient.	Std. Error	Err.
TLO Professional FTEs	16.49	2.16	***
Medical School	-0.71	13.50	
Log of TLO age	14.23	14.69	
Log of Research Expenditures	33.42	9.18	***
Log of Total Office Expenditure	17.56	6.59	***
Turnover in Director	-2.66	1.38	**
Constant	-657.39	154.88	***

N = 53

Table 6: Number of Licenses

Number of Licenses	Coefficient.	Std.	Err.
Disclosures	0.16	0.06	***
TLO Professional FTEs	-0.87	1.37	
Medical School	-3.84	5.67	
Log of TLO age	4.61	6.23	
Log of Research Expenditures	8.89	4.37	**
Log of Total Office Expenditure	6.29	2.97	**
Turnover in Director	-0.39	0.60	
Constant	-173.90	76.73	**

N= 53

Table 11: Frequency of Interaction Across Functions

	Interaction with Industry Sponsored Research			Interaction with Government Sponsored Research		
	Coefficient	Std Error		Coefficient	Std Error	
Organizational Form	-0.486	0.149	***	-0.234	0.132	*
TTO Professional FTEs	-0.004	0.036		-0.050	0.060	
Medical School	0.113	0.412		0.784	0.399	*
Office Age	-0.011	0.016		0.019	0.015	
Log of Research Expenditures	-0.430	0.265	+	-0.092	0.265	
Director's Tenure	-0.222	0.209		-0.045	0.179	
Self-Sufficiency	-0.004	0.006		-0.006	0.005	
No. of Observations	48			50		
LR Chi-squared	16.83*			12.46+		

Table 12: Intensity of Industry Relationships

Independent Variables	Coefficient	Std Error	
Organizational Form	0.44	0.15	***
Self-Sufficiency	0.012	0.006	**

Director Experience	-0.20	0.20	
Office Age	0.03	0.02	
Research Expenditure (Ln)	0.65	0.29	**
FTEs	-0.08	0.06	
Medical School (1=yes)	-0.30	0.45	
Number of Observations	41		
LR Chi-squared	19.54**		

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