TECHNOLOGY TRANSFER IN UNITED STATES UNIVERSITIES:

A Survey and Statistical Analysis

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ABSTRACT

This paper examines the transfer from universities to industry of intellectual property rights in the form of patents or licenses and via start-ups of new companies. Following the Bayh-Dole Act of 1980, many U.S. universities have set up offices of technology transfer (OTT) in order to facilitate commercialization of research results. The purpose of the present paper is to better understand the role of the office of technology transfer: its organization and place within the university structure, the process of technology transfer, and the staffing and funding of the office.

We selected 12 universities ranging from top research universities to some regional universities. The data collection was done through a mail questionnaire followed up through telephone interviews. Besides a detailed descriptive analysis of these survey data we also conducted a statistical analysis of data collected by the Association of University Technology Managers (AUTM) for 170 U.S. universities, hospitals, and research institutes for the period 1991-96.

Our results show that technology transfer from universities to the commercial sector needs to be understood in its broader context. It is not simply a matter of maximizing income for the universities, even though in a few cases quite substantial income is generated. It is rather a matter of finding the proper balance between the basic functions of teaching and research within the universities on the one hand and providing service to the wider community on the other. The primary purpose of a technology transfer program is for the university to assist its researchers in disseminating research results for the public good. Success in this endeavor is only partially reflected in income generated for the university or the number of business start-ups. The degree of success depends not only on the nature of the interface between the university and the business community but also on the receptivity in the surrounding community as well as the culture, organization, and incentives within the universities themselves.

In the sample of universities studied here, the OTT is set up as a unit within the university. In most cases the director reports to the Vice President for Research or Provost, indicating that the activity is regarded as strategically important. The staffing varies from 2 to 18 and the annual budget for licensing and patenting varies from less than $400,000 to $4 million. The larger the OTT, the broader is the in-house expertise, and the more aggressive the pursuit of patents and licenses.

In universities with a medical school, medicine is usually the field most frequently served by the OTT, followed by engineering. Sometimes arts and sciences (particularly chemistry) are also engaged in technology transfer activities.

There are several stages in the technology transfer process, each associated with its own outcome: invention disclosure, patent application, patent issued, license sold, license income and/or business start-up. As a rule, only half of the invention disclosures result in patent applications; half of the applications result in patents; only a third of patents are licensed, and only a handful (10 – 20 %) of licenses yield substantial income. In our sample, the median gross license income in 1996 was $2.2 million and the median income per license was $80,000. License income is shared among the inventor(s), the management center or school, and the OTT according to various formulae. The inventor's share generally varies between 30 and 50 %.

The policies with regard to start-ups vary considerably among the universities. It is noteworthy that while Stanford has a policy not to encourage start-ups, it has generated more start-ups than any other university; only MIT comes close. It almost looks like an inverse relationship: the more active policy the university has, the fewer start-ups can be observed. This may simply indicate that if there are few start-ups, the university needs to take more action. Conversely, if there are many start-ups, no university action is necessary. Thus, there are other things than university policies that explain start-ups.

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INTRODUCTION

Technology Transfer

Technology transfer may be defined generally as "the transfer of the results of research from universities to the commercial sector" (Bremer 1999, p. 2). It may also be more narrowly defined as "the process whereby inventions or intellectual property from academic research is licensed or conveyed through use rights to industry" (AUTM 1998, p. 3).

Technology dissemination or transfer can occur in many different forms. The publication of research results in scientific journals and books is the most common form of dissemination. In some cases the transfer may occur only if the intellectual property is protected and then commercialized. The issue dealt with in this paper is the narrower one of transfer from universities to industry of intellectual property rights in the form of patents or licenses and via start-ups of new companies.

Technology transfer involves at least two parties. As Lawrence Dubois of DARPA puts it, "technology transfer is a contact sport!" The quality and quantity of interaction are determined not just by the interface (the rules of the game, as it were) between the two

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parties but also by what each of the players brings to the game. The knowledge, preparedness, organization, culture, and attitudes of both sides are important for successful interaction. The motivations of the two sides are often quite different. The main objective of basic research is almost never inventions. “If inventions do flow from that research activity, it is largely a fortuitous happening that takes place because the researcher, or perhaps, an associate, has the ability to see some special relationship between his scholarly work product and the public need” (Bremer 1999, p. 4). On the commercial side, the main objective, of course, is profitable exploitation of an innovation or an idea.

The Bayh-Dole Act

The recent increase in university patenting and licensing activity is, at least in part, a consequence of the Bayh-Dole Act, which was enacted by the U.S. Congress in 1980 and became effective on July 1, 1981 (see The Council on Government Relations, 1993). The Act transferred the rights to intellectual property generated under federal grants from the funding agencies to the universities, thus providing the latter opportunities to exploit research results commercially. One of the major arguments for the Act was that a stronger protection of publicly funded research would lead to a faster and stronger technology transfer and hence benefit the taxpayers. The reason behind this argument was that companies need intellectual property rights to pick up, develop, and commercialize the results of university research.

Before the establishment of the Bayh-Dole Act, not many universities found it worthwhile to get into the patenting business since this was connected with a high fixed cost. The Act opened up the possibilities for universities to explore their technology transfer to a larger extent.

There has indeed been an increase in patenting and licensing activity on the part of U.S. universities after the establishment of the Bayh-Dole Act. From 1979 to 1984 the number of patents issued annually doubled (from 177 to 408) and between 1984 and 1989 it doubled again (to 1,008) (Mowery *et al.* 1999). However, some universities such as

Stanford and the University of California were active in technology transfer well before the passage of the Bayh-Dole Act. This means that technology transfer from the universities to industry can not be explained solely by the Bayh-Dole Act. Several other policy decisions were made during this period. For example, in 1980 Diamond v. Chakrabarty upheld a broad patent in the new biotechnology industry which opened the door for many patents in this area. Also, the Court of Appeals for Federal Circuit (CAFC) was established in 1982. The CAFC emerged as a strong protector of the rights of patent holders such as universities.

Following the Bayh-Dole Act, the number of technology transfer offices at U.S. universities increased dramatically. There were 25 such offices in 1980 (before the new legislation), but by 1990 the number had increased to 200. A recent study by Mowery et al. (1998) compares Stanford, the University of California, and Columbia University. The study finds that even without the Bayh-Dole Act, both Stanford and the University of California would have expanded their patenting and licensing activities. Columbia University also made some steps in this direction prior to the Bayh-Dole Act. The study also finds that there has been a change in the attitude and policies regarding the value of research and the potential revenue and profit that it can bring the university. The expanded licensing activities have led to both enthusiasm and resentment over the effect that it might have on the culture and norms of academic research. There is concern that there will be a change in the character of university research towards applied and away from basic research. Yet another study by Mowery et al. (1999) shows the difficulty of managing a technology transfer office with the view of maximizing income. The goals need to be broader than that and be integrated with the entire mission of the university.

Benefits of Technology Transfer to Academic Institutions

Technology transfer programs are important to the academic institutions’ mission of education, research, and public service in that they provide:

- A mechanism for important research results to be transferred to the public;
- Service to faculty and inventors in dealing with industry arrangements and technology transfer issues;

- A method to facilitate and encourage additional industrial research support;
- A source of unrestricted funds for additional research;
- A source of expertise in licensing and industrial contract negotiations;
- A method by which the institution can comply with the requirements of laws such as the Bayh-Dole Act (AUTM Licensing Survey FY 1991 - FY 1995, p. 6). Also, it may be used as
- A marketing tool to attract students, faculty, and external research funding.

Thus, the primary purpose of a technology transfer program is to assist the institution, on behalf of its faculty and inventors, in the dissemination of research results for the public good. The income generated through this mechanism is important but is only a part of the total benefit to the institution. According to the 1996 AUTM survey, the gross license income received by the reporting U.S. universities, hospitals, and research institutions amounted to $500 million. While this is a large amount, it represented only about 2.3 percent of the total sponsored research expenditures in the same institutions. However, among all the reporting institutions the percentage ranges from zero to 11 percent.

It is clear, therefore, that while license income is neither a likely major source of research funding nor the sole (or even the most important) benefit to the institution, some universities are much more successful than others in generating such income. This is one of the reasons for this study: to examine the technology transfer function at U.S. universities with respect to organization, risk management, funding, staffing, and professional competence in order to better understand what successful practices and strategies are.

Benefits to the Community

It may well be argued that technology transfer is even more important to the surrounding communities than to the universities because of the benefits it creates to the rest of the society. In an economic impact model developed by the Association of University Technology Managers (AUTM), it has been shown that nearly $25 billion of the economic activity in U.S. can be attributed to the results of academic licensing,

supporting 212,500 jobs in fiscal year 1996. For FY 1995, the comparable figures were $21 billion and 180,000 jobs (AUTM 1998).

In an article investigating the technology transfer function at Stanford University, Fisher (1998) discusses the many benefits to society of a well-functioning transfer of technologies from the research laboratory to the commercial sector. The income that the technology transfer generates can offset the shrinkage of federal funding in comparison with other sources which has been observed in recent years. The AUTM data show that the share of federal funding in the reporting institutions was reduced from 72 to 66 percent between 1992 and 1996.

The creation of wealth, new jobs and new solutions to problems in the society is another benefit. Fisher describes Stanford's success as a leader in technology transfer and the effect that it has had on northern California's Silicon Valley and the biotechnology industry and its role in providing a model for many other universities across the country as well as internationally. "Stanford continues to show the way, providing creative solutions to new challenges as the need for university research becomes even more urgent… And for the great research universities, income from patent licenses can offset the shrinkage of federal funding" (Fisher 1998, p.76).

It should be noted, however, that Stanford's success in generating new businesses has occurred in spite of a university policy not to specifically promote business start-ups. Thus, success depends not only on university policies and strategies but also on the institutions, entrepreneurial climate, and fertility of the economic soil (including access to venture capital) in the recipient community.

"The real measure of technology transfer is not, of course, the number of patents which the university sector holds, but the amount of technology, represented in and by those patents which has been transferred to the private sector for further development into products and processes useful to mankind" (Bremer, 1999, p. 4). As the Bayh-Dole Act puts it, "the mission of university technology transfer offices is to transfer research results to commercial application for public use and benefit… The major effort of the office is to find companies which have the capability, interest and resources to develop embryonic technologies into useful products" (The Council on Governmental Relations, 1993, p. 2).

Thus, a full evaluation of the output of the technology transfer process is a complex matter. The income from licenses and the number of start-ups are at best only partial measures. Not much is known about this, although a recent study finds that license income increases more than proportionally with R&D expenditures (Siegel, Waldman & Link, 1999, p. 20).

Focus and Organization of the Paper

The focus in this report is on various activities and parameters associated with the technology transfer process on the university side. In the AUTM report several different parameters are presented that can be used to measure technology transfer. The general stimulus for the basic process is research expenditure. Most universities use this variable on the input side to evaluate the technology transfer activity. The most common output variable is number of licenses. It is logical to expect that the larger are the resources spent on research and development, the more licenses and options will be generated. Indeed, recent studies (Adams & Griliches, 1996, and Siegel, Waldman & Link, 1999) have shown constant returns to scale in this respect, i.e., that the number of licensing agreements increases proportionally with R&D expenditures. The size, distribution and significance of the parameters describing the technology transfer function are also of interest and will be explored further in our statistical analysis.

The fact that the history, organization, and performance of technology transfer vary from one institution to the next provides a major motivation for this study. Are there certain practices that are more successful than others? How do offices of technology transfer (OTTs) fit within the organization (and overall mission) of the university? What differences can we observe in levels and sources of funding, staffing, and professional expertise? What role do differences in attitudes and procedures with respect to risk management play? How widely do attitudes and procedures with respect to licensing and

start-ups differ? Is there a "model" that can be emulated? These are the general questions which prompted the Edison BioTechnology Center (EBTC) to initiate and fund this study.[1] They are also the main questions addressed in the in-depth survey we conducted with twelve U.S. universities, reported in the next section.

In addition to answering these questions concerning the technology transfer organization and process with the help of the questionnaire survey, we have used the insights gained from this analysis in carrying out a statistical analysis of the annual survey data collected by the Association of University Technology Managers, Inc. (AUTM). Our aim is to highlight the technology transfer process and some of the most common performance measures that the universities themselves use to evaluate their activity. We have also examined the correlations among the variables and how this can help us understand the technology transfer function. In addition, we have built a simple model, based on our own survey results, which can be used for multivariate econometric analysis. We then used this model in a regression analysis.

It is important to keep in mind that this report focuses primarily on the practices in universities with respect to technology transfer. Thus, it covers only one side of the equation. A more comprehensive report would also cover the absorptive capacity of the actors on the commercial side, as well as the environment supporting the transfer activity. We have not found any such study in our literature review. Such a report would also have to deal with the further complexities arising from the fact that the interaction is different in different technology areas and in different environments. Many studies show that the benefits of technology transfer (often referred to in the economic literature as technological spillovers) are largely local (Bania, Eberts and Fogarty, 1993; Jaffe, Trajtenberg, and Henderson, 1993; Zucker, Darby, and Brewer, 1998; Zucker and Darby, 1996; Audretsch and Stephan, 1996).

[1] EBTC is a part of the Ohio Department of Development's Thomas Edison Program which constitutes the backbone of Ohio's technology policy.

The paper is organized as follows. The next section analyzes the results of our survey of the technology transfer function in twelve United States universities. Using the insights gained from this survey we then proceed to a statistical analysis of AUTM data. The paper concludes with a discussion of the results and their implications.

QUESTIONNAIRE SURVEY OF TECHNOLOGY TRANSFER IN U.S. UNIVERSITIES

Information on the Survey Data Collected

We chose 12 universities ranging from top research universities to some regional universities. The universities are The California Institute of Technology, Carnegie-Mellon University, Case Western Reserve University, Emory University, The Ohio State University, Stanford University, The University of Cincinnati, The University of Michigan, The University of Pennsylvania, The University of Texas Southwestern Medical Center, Vanderbilt University, and Washington University.

The data collection was done through a mail questionnaire followed up through telephone interviews. Nine universities responded to the questionnaire; thus, the response rate was as high as 75 percent. The questionnaire included 31 questions divided into three parts. See appendix A.

The data reported here include both the survey data and the background data for each university obtained through the AUTM reports. Thus, some data are available also for the universities which did not respond to our survey, as well as an additional university in Ohio not included in the survey.[2]

[2] We will refer to this data set as the subset n, and we will refer to the data set collected by the AUTM as the total sample, N.

Organization, Staffing, and Funding

Table 1 provides overview data on the organization, staffing, and funding of technology transfer in the universities covered by the survey. In the table, the universities are ranked in descending order of their annual research budget. Two of the universities had set up their office of technology transfer (OTT) prior to the Bay-Dole Act. In the other cases, the OTT was established somewhere between 1982 and 1990 with 1986 as the median for the sample as a whole.

In all of the universities surveyed, the OTT is set up as a unit within the university, not as a corporation or other entity separate from the university. In all but two cases the director of the OTT reports to the Vice President for Research (or equivalent position). In the two exceptional cases, the director reports to the Provost and in one case also to the Chancellor for Health Affairs. Thus, there is no doubt that technology transfer is regarded as a matter of strategic and policy concern at the highest level within the universities. How high a priority is placed on these activities varies from one university to another, however.

There is only one technology transfer office at each university, except that in two cases there is also a branch office in the medical school. In one of the universities the OTT also has responsibility for handling industrial grants and in another case works closely with an office handling such grants (as distinct from federal funding).

Staffing and Expertise

The size of the OTT in terms of number of staff members ranges from 2 fulltime equivalents (FTEs) in the smallest institution to18 in the largest, 4.5 being the median number. In most cases, the number of professionals is significantly larger than the number of support staff. In the schools with a small OTT, basic science is the dominant type of expertise. As one would expect, the larger the OTT, the broader is the range of in-house expertise. In three cases there is legal expertise within the OTT itself; in one of these cases that is the only professional expertise represented.

Risk Management and Legal Expertise

The management of the risk exposure associated with technology transfer is a sensitive and serious issue at most universities. A common method is to accept no liability resulting from technology transfer but to require licensees to indemnify the university if liability should occur (or to obtain the necessary indemnification insurance coverage). This is the method used in four of the surveyed universities. However, this may not work in cases when the potential licensee is a small start-up. In such cases, other solutions have to be found (including not issuing a license at all).

For risk management purposes but also for handling of intellectual property issues, as well as other reasons, legal expertise is often required in connection with technology transfer. This expertise may reside in a variety of places. Six of the nine responding universities have no legal expertise at all in the OTT. Of these, four require indemnification by licensees. All of the universities have a university attorney's office and/or risk management office. Four of the universities obtain legal advice from outside firms concerning matters of intellectual property, while one university has its own intellectual property office.

Annual Budget and Research Funding

The annual budget for licensing and patenting activities within the OTT ranges from $320,000 to over $2 million. A substantial portion of the difference is explained by the size of license income. Apparently, license income is a major source of funding of technology transfer activities in most universities.

The university-wide annual research budget in the reporting institutions ranges from $13.5 million to $441.3 million, with a median of $165 million. This should be compared with a median of $96 million for all the schools included in the AUTM report. The correlation between the annual budget for licensing and patenting on the one hand and the annual research budget on the other is very low.

The Technology Transfer Process

The steps to transfer or commercialize a technology are basically the same at all universities. Typically, the process starts with the faculty/researcher/inventor submitting an invention disclosure form (a standard form specified by the university) to the OTT. After reviewing the disclosure, investigating the potential market, and estimating whether or not the expected return warrants the cost of seeking intellectual property protection (patent, copyright, trademark, or other form of protection), the OTT initiates the requisite application. All the universities surveyed claim to actively facilitate patenting, but always within the constraints set by the budget (the patenting cost typically being somewhere in the $15,000 - $20,000 range per application). In all but one of the universities, patent applications are handled by the OTT; in the remaining case an outside firm is used.

Once intellectual property rights have been obtained, technology licenses are typically developed in several stages:

a) **Confidentiality or Non-Disclosure Agreement (NDA)** – If confidential matters need to be disclosed by either party to the other in order to permit substantive discussions, a Non-Disclosure Agreement between the potential licensee and the university will be developed. In some categories of cases a similar arrangement is obtained through a **Material Transfer Agreement (MTA)**.

The typical process for a nondisclosure agreement (NDA) or confidentiality agreement is to start with a standard agreement form. If the standard form is acceptable, the process is usually completed within a day or two. If a non-standard agreement must be negotiated, the process varies from case to case as to its duration and the personnel involved. In most universities, the OTT officers or director have sign-off authority, but in one case the provost has to sign and in another legal counsel has to be sought.

The process for material transfer agreements (MTAs) is similar to that for NDAs. In standard cases, the process can usually be completed within a day or two and is handled entirely within the OTT. But in some universities, other offices process MTAs. In one case, the provost's signature is required. See table 2.

b) **Business Plan** – In order to have a substantive discussion of a potential license, the university will also need to understand the nature of the Licensee's current business, his/her future business plans, and the specific plans for utilizing, developing and commercializing the technology expected to be licensed ("Licensed Technology").

In the case of well established, robust companies with demonstrated record of revenues, profits, technologies and products, such a business plan will concentrate on the specific development of the licensed technology, the resources to be used, expected development milestones, and the economic results expected, to demonstrate that the licensee intends to develop that technology to the fullest and has the know-how and the resources to do so. In the case of start-ups or newly established firms, the business plan may involve the development of the whole company and its business strategy.

c) **License Term Sheet** – Based on the above, the next and typically the most important step will be the discussions of the key economic terms of the proposed license, resulting in a tentative agreement on terms as defined in a "License Term Sheet".

d) **License Agreement** – Once a basic agreement on economic terms has been reached, the next step is to draft the actual license agreement, i.e., the legal document which incorporates both the economic and other terms of the terms sheet as well as the university's general licensing terms and conditions (commonly also called "legal boiler plate").

In contrast to NDAs and MTAs, there is no standard procedure for license agreements. The process usually starts with a standard form, but modifications and therefore negotiations are always necessary. The time required to reach an agreement varies from a few weeks to several years.

The university personnel involved in these negotiations are the licensing associates of the OTT, plus the inventor or researcher. In one case the OTT director is also involved, along

with the university's legal counsel. In another case, in addition to these, the university risk manager also takes part in the negotiation. The authority to sign off on licensing agreements resides in the OTT in all but two cases, the remaining two requiring the signature of the V.P for research or even the provost.

How active a role the university plays in finding potential licensees depends largely on the resources available, particularly the number and capabilities of the OTT staff. In one case, the OTT explores many avenues in trying to locate licensees, including contacting existing licensees and other corporate contacts, searching corporate technology directories, and conducting on-line literature searches. However, by far the best source of potential licensees is the inventors themselves, since they are likely to know who in industry is doing work related to their inventions. They are often aware of companies that might successfully commercialize their inventions. The OTT encourages companies to indicate what areas are of interest to them; thus providing a "wish list" of technologies. Often the assessment of the commercial potential of an invention begins by conducting literature searches and by asking contacts in industry for input.

Patenting and Licensing Activities

The patenting and licensing activities in the universities included in our survey are summarized in table 3. With only two exceptions, medicine is mentioned as the school or field most frequently served by the OTT at universities which have a medical school. Engineering is the second most frequently mentioned field. The number of invention disclosures reported for FY 1996 varies from 22 to 300, with a median of 63. The number of patent applications ranged from 4 to 130, with a median of 34. The median number of U.S. patents issued in FY 1996 was 16, i.e., about half the number of applications. In other words, ignoring the time lags between disclosure and application and between application and issuing of patents, only about half of the invention disclosures resulted in patent applications, and only half of the applications resulted in actual patents. Furthermore, only a fraction of patents yield license income. Of the 1,747 active licenses and options in the surveyed universities in FY 1996, 682 (39 %) yielded income. The average license income to the university was $5.9 million, meaning that the average income per license was $180,000. However, the mean was only $80,000. This means that the distribution of income-yielding licenses is highly skewed; with the exception of only one university, the number of patents generating more than $100,000 per year is six or less.

Policies and Procedures for Start-Ups

The number of start-ups is another indicator of technology transfer performance. The policies and procedures for start-ups depend in large measure on the university's attitude towards risk and the capabilities in the surrounding business community. As already noted, one university (Stanford) has a policy of not creating or helping to create spin-offs (Roberts & Malone, 1996)– and yet has more start-ups to its credit than any other university (AUTM Survey). Thus, the university's policies are not the only determinant of spin-offs and their degree of success; the history, culture, attitudes, industry affiliation, market orientation, etc., of existing businesses, and the presence or absence of venture capital, as well as the vigour and diversity of supporting organizations and institutions are also important. At other universities included in our survey, the attitude towards start-ups ranges from reluctance to play a role in spin-offs at one extreme, to refraining from initiating spin-offs but helping them once underway, and to active encouragement of and involvement in creating spin-offs (including incubation services, financial support, and information/networking services) at the other extreme.

The survey data on start-ups are summarized in table 4. The table shows little correlation – or perhaps even a negative one – between the university's attitude toward start-ups and performance as indicated by the number of new companies formed.

Industry-Sponsored Research

As shown in table 5, industry-sponsored research amounted to $192 million in FY 1996, or 7.3 percent of the total research budget in the surveyed institutions. The share of industry-sponsored research remained constant between FY 1991 and FY 1996. (Meanwhile, as noted earlier, the share of industry-sponsored research increased in the entire population of universities included in the AUTM surveys.)

Policy with Respect to Exclusive vs. Non-exclusive Licensing

Six of the universities included in our survey report that they have no policy with respect to exclusive or non-exclusive licensing agreements. One university grants only exclusive licenses, while another one usually offers exclusive licenses. One university offers exclusive license options to industry sponsors.

Patent Ownership and Sharing of License Income

In the event that the university is not interested in pursuing a patent, the ownership rights are usually reassigned to the inventor. In a few cases the university retains patent ownership but licenses it back to the inventor. License income is shared between the university, the management center of the inventor(s), and the inventor(s). As shown in table 6, the formulae pertaining to income sharing vary. The inventor's share is typically 30 – 50 percent of the net income (i.e., gross income minus legal fees and other expenses).

Monitoring of Royalty Agreements

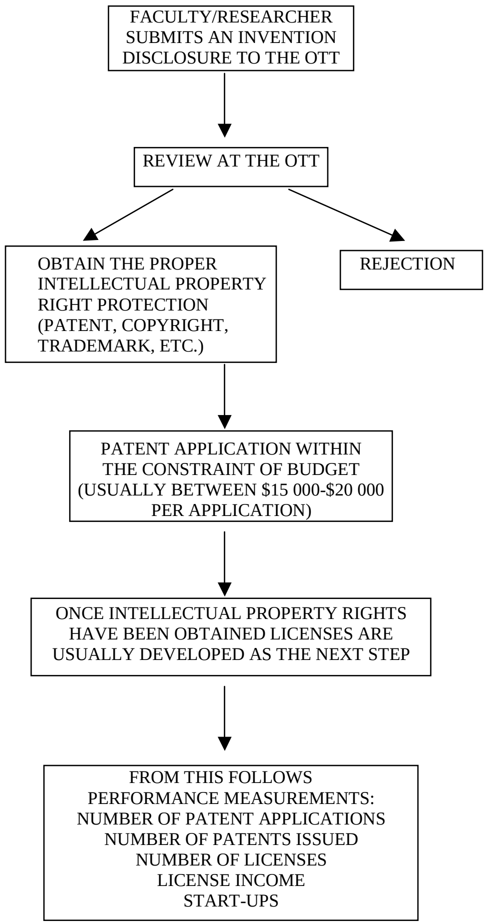
Several of the surveyed universities have effective procedures in place for monitoring royalty agreements, including computerized methods. However, a few of the respondents indicate dissatisfaction with current procedures, and several universities are taking steps to improve the monitoring. Staffing levels and the relatively low priority placed on this activity seem to be the main constraints.

Proposed Success Indicators

When asked what they regard as good indicators of performance or success in technology transfer, technology managers come up with a number of suggestions. These include the measures incorporated in this study, particularly the number of patents and licenses and the amount of royalty income. The number of invention disclosures is also often mentioned. A few of the respondents also mention the broader and harder-to-measure aspects of performance, such as the number of spin-offs, faculty satisfaction, and general indicators of overall transfer activity.

We can now summarize the technology transfer process given by the results of the study as shown in figure 1.

Figure 1. The process of technology transfer and the most common performance measurements



Statistical Analysis of the Questionnaire Survey Data

The technology transfer process can be described in terms of an input-output model in which the inputs are research expenditures and OTT staff and expertise and the outputs are the results of the various stages of the technology transfer process. It is important to note that what is output from one stage of the process can be an input to another stage. For instance, invention disclosures may be regarded as an output but may also be used as an input in the patent application stage.[3] When describing the interaction between the industry and the university, a model of ‘two-way’ interaction is a more appropriate way of expressing the links between them. A study by Meyer-Krahmer and Schmoch (1998) shows that collaborative research and informal contacts are the most important interactions between universities and industry and that industrial firms are important producers of new knowledge which in turn is useful for academic research.

As indicated above, it may be expected that the more resources are spent on R&D, the greater the expected outcome. Therefore we expect a high correlation between total research expenditure and the number of licenses and patents, leading to license income.

An interesting aspect is whether, in fact, those universities that spend the most money on R&D are also the ones that have the largest number of active licenses and patents and the highest royalty income. Table 7 shows the research expenditure and the cumulative active licenses per institution. The universities are ranked in descending order by the total research budget. The table gives an indication of the correlation between the input research expenditure and the output licenses and options in the technology transfer process.

The correlation between the two variables Total Research Expenditure and Cumulative Active Licenses and Options is high, 0.599. A simple linear OLS (Ordinary least squares) regression shows that Total Research Expenditure has a high explanatory power, explaining as much as 35 percent of the variation in the number of licenses and options. It is also significant as indicated by the t-value (on the 5 % level) in explaining the number of licenses and options. If we look at all 212 universities in the AUTM survey, the relationship is even tighter: the corresponding figures are 0.99 and 99 percent, respectively. The correlation between the number of licenses and options and license income received is also high: 0.975 in our subset and 0.988 in the AUTM population.

STATISTICAL ANALYSIS OF THE AUTM SURVEY DATA 1991-1996

Data Collected by AUTM.

This section is based on two data sets, one for 1996 and one covering the period 1991-95. Both data sets include both the entire population of universities surveyed by the AUTM and the subset of universities included in our own questionnaire survey.

The AUTM survey population for 1996 consisted of 300 institutions: 212 U.S. universities, 55 U.S. hospitals and research institutes, 28 Canadian institutions, and 5 third-party management firms. 58 percent (173 organizations) responded to the survey, including 131 U.S. universities, 26 U.S. hospitals and research institutes, 14 Canadian institutions, and 2 third-party management firms. The response rate from the universities, 62 percent, is somewhat higher than the overall response rate. There is a small over-representation of the top universities since the follow-up efforts were concentrated on the top 100 universities. This should not affect the results of the technology transfer function, which is the main focus of this report. For the purpose of our analysis, only the U.S. universities are included in the presentation of the data set which we will refer to as N, the total sample.

Statistical methodology

The data material was processed with the SPSS software. The correlations were calculated using the Pearson correlation coefficient and the regressions using linear regression, OLS (ordinary least squares).

[3] It would also be possible to describe the process in a more complicated model with feedback but we would then lose simplicity and transparency without necessarily obtaining better models.

The AUTM has collected information about more than 30 variables that all have to do with technology transfer. We have chosen to look more closely at variables emphasized as important by the universities included in our survey and what other researchers have pointed out as important in the literature. See tables 8 and 9.

As can be seen in the tables, looking at the whole data set, most of the technology transfer offices were started in the mid 1980s. This does not mean, however, that there was no such function before that time. Many universities engaged in technology transfer even without such an office. Some universities have a big office with more than 100 professional and support staff, but the mean is only 5.2 professional and support staff indicating a much more modest size of the technology transfer office in most universities. In the subset, the corresponding figures are 18 professional and support staff as maximum, while the mean is somewhat higher than for the whole group, 6.6 professional and support staff.

The total research expenditures vary strongly among the universities. The range is from $5 million to as high as $1.5 billion. The average expenditure is $142 million. As these numbers indicate, the standard deviation is large, $180 million. In the subset, the variation is somewhat smaller, from $13 million to $441 million. On average, the universities spend about $203 million. The standard deviation in the subset is also smaller, $124 million.

What can we say about performance? The number of active licenses represents one measure. This variable varies between 0 and 903 licenses. Overall, the mean is 82 licenses with a standard deviation of 137. Perhaps even more interesting is the license income which varies from 0 to $63 million. On average, the universities have an income of about $2.7 million from licenses. The standard deviation is $7 million. In the subset, the number of active licenses ranges from 6 to 903, with a mean of 145 licenses and a standard deviation about 245. The license income varies between $543,000 and $43 million. The average income is $5 million, and the standard deviation is as high as $11 million.

It is even more interesting to look at the licenses and options generating license income. As shown previously, there are only a few very successful licenses that generate a large amount of income; most licenses do not. The number of licenses producing income ranges from 0 to 513. The average is 38 licenses per university and the standard deviation is 63. In the subset the number varies from 1 to 259. The average the number is 52 with a standard deviation of nearly 70.

Another output variable is the total number of patents which varies between 0 and 325 applications filed. The average number is approximately 30, and the standard deviation is 40. For the subset, the number of applications varies between 4 and 130. On average, there are 45 applications per university and the standard deviation is 40.

The number of start-ups initiated varies from 0 to 14 with a mean of 1.4. The standard deviation is 2.3. In the subset, the maximum is the same but the mean is somewhat higher, 3.2. The standard deviation is also higher than for the whole group, 4.6.

Looking at the correlations among some of the variables can give us some more information. See table 10 for details. Overall, the correlations are very high, indicating that there are strong linkages between the variables.

Following the process of technology transfer as outlined in figure 1 it becomes clear that the technology transfer process involves a sequence of events. It starts with the invention disclosure leading to a review; then the disclosure is either rejected or accepted, usually with some adjustments. The next step is to look for the right kind of property right protection such as a patent. Once intellectual property rights have been obtained, licensing is likely to be the next step. In some cases, the end result is a start-up. Since it all depends on the previous step in the chain, we decided to build several models using the performance measures as our dependent variables. The models are described in

Matrix 1 below. One important factor that has to be incorporated in the models is time. Once a patent has been issued, it can take years before a license is executed. The same is true for license income. It depends on what has happened in the past; the path dependency is strong. The different steps in the technology transfer process can be described in several models. More models than are being shown have been tested and analyzed, but only the most relevant and significant will be presented here.

As mentioned in the introduction, our main focus is on capturing the variables that can explain or give an indication of the universities' technology transfer process and activity. The most common output variables are the number of patents and the number of licenses. The output variables of greatest interest here the number of total patents, the number of new patents, the number of U.S. patents issued, license income, the number of licenses, and the number of start-ups. These variables are our dependent variables and will be noted by Y. Concerning independent variables, i.e., variables that might explain the technology transfer activity, we assume that the more money is spent, the more activity can be expected. Examples of input variables are: research expenditures, number of invention disclosures, number of employees (i.e., number of staff), and the number of years that the OTT has been operating (we expect to find a learning curve). We will note the input variables with X.

The reason that we do not include the year in which the OTT was established (referred to as "program year"), total FTEs, and total research expenditures as input variables in all our models (they are included only in the first two and the last one) is the sequential nature of the process: the output of one step may be input in the next. Therefore, we expect the three variables mentioned above to be incorporated already. The correlation matrix (table 10) shows that there are strong links between all the variables. We would therefore have to deal with multicollinearity (covariation among the independent variables) which could lead to incorrect estimation of the regression coefficients. The variables could even have the "wrong" signs. In the presence of multicollinearity, the effect of each variable on the dependent variable cannot be determined.

Matrix 1. The technology transfer process step by step

Invention disclosure = b_1*program year + b_2*total expenditure + b_3*staff + e
Total patent application = b_1*program year + b_2*total expenditure + b_3*staff + e
Total patent application = b_4*invention disclosure +e
New patent application = b_4*invention disclosure + e
US patent issued = b_5*total patent app. + e
US patent issued = b_6*new patent app.+ e
Licenses = b_7*patent issued $_{(t-1)}$ + e
Licenses = b_5*total patent app. $_{(t-1)}$ + e
Cumulative licenses = b_5*total patent app. + e
License income = b_8*cumulative licenses + e
Start-ups = b_1*program year + b_2*total exp. + b_3*staff + e

t stands for time

To estimate the models we used linear regression, OLS. The results from the regressions are shown in tables 11 and 12.

The higher the coefficient of determination (R^2), the greater is the explanatory power of the regression and hence the better is the prediction of the criterion variable. R^2 expresses the level of the prediction accuracy. It varies between 0 and 1. The strength of the relationship between the variables is represented by R^2, which tells us how much of the variation in Y is explained by X (in percent). The sign of the correlation variable (r) denotes the slope of the regression line, but its value can mislead one to think that a stronger relationship exists between the Y and the independent variables than is actually the case. See table 10 for the correlation matrix. R^2 adjusted is used to compare different models with each other, i.e., to compare equations involving different numbers of predictors or different sample sizes. By using R^2 adjusted we can compare the results from the whole sample (N) with our subset (n). The Beta values (β) reflect the relative impact on the criterion variable of a change in one standard deviation in either variable,

i.e., it tells us which variable is the most helpful (has the strongest impact) in predicting the dependent variable. We have chosen to give the beta value when dealing with multiple regression equations, see tables 11 and 12. The regression coefficient (b) reflects the expected change in the dependent variable for each unit change in the independent variable if all others are held constant.

As we expected from the correlation matrix, the overall R^2 values are high, indicating that we can predict the dependent variable fairly confidently. Invention disclosures can to 83 percent be explained by program year, total research expenditures, and number of staff. For the subset this is lower, 34 percent. The variable that has the strongest impact on invention disclosures is total research expenditures, but for the subset it is the number of staff which has a negative (but statistically insignificant) impact on invention disclosure. Comparing the subset with the whole sample, it does not look like our sample is very different from its population. However, an exception is that in our sample, 95 percent of the variation in license income is explained by the number of cumulative licenses, whereas for the whole sample the corresponding figure is 62 percent. This means that adding one more license to the number of cumulative licenses has a rather large impact on license income. As indicated by the regression, it increases the license income by $45,590 and for the sample by $48,461 on an average basis. But we have not captured all the explanations behind license income. Licensing may not be appropriate for all inventions, and certainly chance (or luck) plays an important role.

One of the variables that is hard to predict is the number of start-ups. The only variables we can use as explanatory variables are program year, total research expenditures, and number of staff. Together they explain 38 percent of the variation in the number of start-ups. For our subset we can explain as much as 80 percent with the same model. These results show that there is more to start-ups than money and number of employees at the OTT. Earlier in the report we have mentioned that such things as culture and surrounding environment can have a big impact on entrepreneurial ability.

Conclusions

It is clear from this survey that technology transfer from universities to the commercial sector needs to be understood in its broader context. It is not simply a matter of maximizing income for the universities, even though in a few cases quite substantial income is generated. It is rather a matter of finding the proper balance between the basic functions of teaching and research within the universities on the one hand and providing service to the wider community on the other. The primary purpose of a technology transfer program is for the university to assist its researchers in disseminating research results for the public good. Success in this endeavor is only partially reflected in income generated for the university or the number of business start-ups. The degree of success depends not only on the nature of the interface between the university and the business community but also on the receptivity in the surrounding community as well as the culture, organization, and incentives within the universities themselves.

In the sample of universities studied here, the OTT is set up as a unit within the university. In most cases the director reports to the Vice President for Research or Provost, indicating that the activity is regarded as strategically important. The staffing varies from 2 to 18 and the annual budget for licensing and patenting varies from less than $400,000 to $4 million. The larger the OTT, the broader is the in-house expertise, and the more aggressive the pursuit of patents and licenses. The steps to transfer or commercialize a technology are basically the same at all universities, as illustrated in figure 1. In most cases, sign-off authority on Non-Disclosure Agreements, Material Transfer Agreements, and licenses resides within the OTT.

In universities with a medical school, medicine is usually the field most frequently served by the OTT, followed by engineering. Sometimes arts and sciences (particularly chemistry) are also engaged in technology transfer activities.

There are several stages in the technology transfer process, each associated with its own outcome: invention disclosure, patent application, patent issued, license sold, license

income and/or business start-up. As a rule, only half of the invention disclosures result in patent applications; half of the applications result in patents; only a third of patents are licensed, and only a handful (10 – 20 %) of licenses yield substantial income. In our sample, the median gross license income in 1996 was $2.2 million and the median income per license was $80,000.

In our sample, industry-sponsored research maintained its share of about 7 percent of total research expenditures over the period 1991-1996. The share in 1996 varied between 4 % and 20 % in the institutions surveyed.

License income is shared among the inventor(s), the management center or school, and the OTT according to various formulae. The inventor’s share generally varies between 30 and 50 %. Monitoring of royalty agreements is carried out routinely in some universities but seems to have received low priority in several cases. No general agreement seems to exist regarding indicators of success in technology transfer activities.

The policies with regard to start-ups vary considerably among the universities. It is well known that MIT and Stanford University have an excellent record of interacting with the local community to create new business ventures. MIT’s role in the so-called ‘Route 128 phenomenon’ (Saxenian, 1996) is well known. An average of 25 companies spun off from MIT during each year in the 1980s. The same pattern is found in California’s Silicon Valley originating from research carried out at Stanford University (Roberts and Malone, 1996).

It is interesting to note that while Stanford has a policy not to encourage start-ups, it has generated more start-ups than any other university; only MIT comes close. It almost looks like an inverse relationship: the more active policy the university has, the fewer start-ups can be observed. This may simply indicate that if there are few start-ups, the university needs to take more action. Conversely, if there are many start-ups, no university action is necessary. Thus, there are other things than university policies that explain start-ups. In the entrepreneurial literature culture, personality, and networks are often mentioned as conducive to new ventures. A recent report by Bank of Boston (1997) investigating companies founded by MIT graduates emphasized that MIT encourages its students to become risk-takers and to start their own business. It is also well established that children of entrepreneurs are more likely than others to become entrepreneurs – another indicator of the importance of culture and tradition in the surrounding community. As mentioned in the introduction, we are only investigating one side of the coin, the university side. In order to get the whole picture we would have to include the other part as well, which is beyond the scope of this report.

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Table 1.Technology Transfer in U.S. Universities - Organization, Staffing and Funding

AUTM-data from FY 1996, (*) Indicates data from interview material

University	Year OTT started	Reports to: (*)	Staffing (FTEs),	Staffing (FTEs) (*)	Expertise (*)	Legal Expertise in OTT (*)	Outside legal advice from (*)	Annual Budget for licensing & patenting (*)	University Annual Research Budget ($M)
5	1982	VP Research	15.25	7 professionals, 10 support staff	Basic science; legal (1); mgmt (1)	Yes	Univ. Risk Mgr.	Total Budget $2M; patenting $500K	441.3
4	1970	VP Research	18	20 professionals, 5 support staff	2 biotech; 2 physical science; 2 both engineering; industrial experience	No	Univ. Risk Mgr; Outside IP firm	Total Budget: $2.2M. For patenting: $2M. License income $700K	395.5
8	1978	VP Research	4	3,5 professionals, 2,5 support staff	MBA (1); PhD in science (2); legal (1)	Yes	Univ. IP office	Total budget: $4M; for patenting: $750K	218.0
6	1990	VP Research	4	4 professionals, 2 support staff	Basic & pol science (1); genetics(2); Ind. Engin. (1)	No	Univ. Office of Legal Affairs. IP: outside firm	Patenting budget: $400-500K. License income $200-300K	207.7
3	1992	Provost	5	4 professionals, 2 support staff	Engineering; basic science; MBA	No	Outside firm	N.A.	165.0
9	1985	VP Research	4.5	3 professionals, 2 support staff	Basic science, business	No	Univ. Office of General Councel	Patenting budget: $855K. License income $580K	146.0
1	1986	VP Research	3.5	2 professionals, 1 support staff	Legal (2)	Yes	Univ. Attorney & Univ. Risk Mgr.	Total budget: $320K; for patenting: $90K	140.6
7	1990	Provost & V. Chanc.- Health Affairs	2.25	2.5 professionals, 4 support staff	Elec. Engin.; life sciences; business	No	Univ. Attorney	Total budget $580K; for patenting: $150K	128.5
2	1983	VP Research	3.5	2 professionals, 1 support staff	Basic science (1); legal (1)	No	Univ. Risk Mgr.	Total budget: $389K; for patenting: $154.2K; license income $136.5K)	64.4
10	1986		11						328.0
11	1985		6.3						250.0
13	1990		6.05						144.1
12	1991		2						13.5
Median	1986		4.5						165.0

Table 2. Technology Transfer in U.S. Universities - Licensing Procedures

Data from interview material

University	NDA negotiated by	Duration of process for standard agreement	NDA sign-off by	MTA sign-off by	Licensing: Personnel involved	Licensing sign-off authority	Role in finding licensees	Number of professional staff	Indemnific required
1	OTT, researcher, Univ. attorney, Univ. risk mgr	1-2 days	Provost	Provost	OTT, researcher, Univ. attorney, Univ. risk mgr	Provost	Modest role (limited by resources)	2	Sought but not always required
2	OTT officers	1 day	OTT officers	OTT officers	OTT officers	OTT officers	?	2	Yes
3	OTT officers	Varies	OTT after consultation with legal counsel	N/A	OTT director, licensing officer, Univ. legal counsel	OTT after consultation with legal counsel?	?	4	Yes
4	OTT officers	1 day	OTT officers	OTT officers	OTT officers	OTT officers	Active search via existing licensees, corporate contacts, directories, on-line searches	20	Yes?
5	OTT officers	1 week	OTT director?	Incoming: Dept. of Research Admin.; outgoing: OTT officers?	OTT officers	OTT director?	Fairly active	7	?
6	OTT officers, with input from legal counsel	A few days	OTT director	OTT director?	OTT officers, with input from legal counsel and inventor	OTT director	?	4	Yes
7	OTT officers?	?	?	Div. of Sponsored Research in Provost's office	Inventor; OTT officers	?	Relies on existing network and researcher's contacts	2.5	?
8	OTT officers	?	OTT officers	OTT officers	OTT officers	OTT officers?	Relies on existing network and researcher's contacts	3.5	?
9	OTT officers?	Varies	OTT officers	OTT officers	OTT officers	VP Research	?	3	?

Table 3. Technology Transfer in U.S. Universities - Patenting and Licensing Activities

AUTM-data from FY 1996, (*) Indicates data from interview material

University	Medical School	Schools and departments most frequently served by OTT (*)	Invention disclosures received FY1996 (AUTM)	FY1996 U.S. patent applications (AUTM)	FY 1996 U.S. Patents Issued (AUTM)	FY1996 licenses & options yielding license income	Total active licenses & options 1996	FY1996 Gross License income	FY 1996 income per license	FY 1998 Patents generating more than $ 100.000 (*)
8	No	Biology, chemistry, chemical engineering, applied engineering, applied physics, computers	300	120	31	35	N.A.	$3,900,000	$111,429	3
4	Yes	*Engineering:* electrical. *Medicine:* various. *Various laboratories.*	160	130	56	259	903	$43,752,059	$168,927	20
10	Yes		136	54	46	29	94	$782,000	$26,966	
5	Yes	*Medicine. Engineering.*	112	65	23	82	142	$1,074,747	$13,107	6
3	No	Computer science, robotics. *Engineering:* electrical & computer. *Arts & sciences:* chemistry	83	18	8	13	43	$7,135,262	$548,866	4
13	Yes		73	23	16	49	82	$2,939,965	$59,999	
6	Yes	*Engineering:* electrical, mechanical. *Arts & sciences:* physics, chemistry. Pharmacy. *Medicine:* HLI, surgery, internal medicine, OB/GYN. *Agriculture & veterinary:* food animal health, veterinary biosceinces, horticulture & crop science, food science.	63	49	21	25	78	$1,096,700	$43,868	3
9	Yes	*Medicine*	63	34	11	17	38	$2,580,000	$151,765	5
7	Yes	*Medicine* (70-75 %). *Engineering* (10-15 %).	58	10	7	27	67	$640,288	$23,714	4
1	Yes	*Medicine:* various. *Engineering:* biomedical, materials science, electrical. *Arts & sciences:* physics, biology, chemistry	43	15	8	17	37	$543,397	$31,965	3
2	Yes	*Medicine:* molecular genetics, internal medicine, surgery, many others. *Arts & sciences:* chemistry. *Engineering:* chemical eng., civil & environmental, electrical & computer, mtrls science	38	23	8	11	39	$2,207,682	$200,698	1
11	Yes		22	44	20	117	218	$9,413,429	$80,457	
12	Yes		22	4	5	1	6	$874,262	$874,262	
Median			63	34	16	27	73	$2,207,682	$80,457	4

Table 4. Technology Transfer in U.S. Universities - Start-Up Activities

AUTM-data from FY 1996, (*) Indicates data from interview material

University	Attitude to start-ups (*)	FY 1996 Start-up companies formed	Start-up companies formed 94-96
1	University plays no active role in spin-offs, but affiliated organizations sometimes do. The university prefers licensing to large companies rather than to get involved with start-ups.	1	5
2	N.A.	0	1
3	Actively involved in the start-up process, helping out in the commercialization process via documentation package, Incubation service, financial support (cash $20K and credit $30K)and contacts with several organizations	2	3
4	OTT is not in the business of creating or helping with spin-off or start-up companies.	14	25
5	Actively involved and encourages start-ups. OTT has one person working full time with this. The state provides information and contacts with venture capitalists but offers no direct financial help.	8	9
6	OTT plays an active role in securing technical and financial support. Spin-offs also have access to a local incubator.	0	0
7	Actively involved with the start-up process. The university has an organization specifically for this. There is also an investment fund of $10K available. Has hired a person with commersialization experience for this matter.	1	1
8	Actively involved in the start-up process, helping out in the commercialization process. About 1/3 of all license agreements involve start-ups.	10	16
9	OTT helps with start-ups but does not initiate them.	0	3
10		4	16
11		1	4
12		0	1
13		0	3

Table 5. Technology Transfer in U.S. Universities - Industry Sponsorship

AUTM-data from FY 1996, (*) Indicates data from interview material

University	Annual Budget for licensing & patenting (*)	Annual Research Budget 1996 , $M	Industry-sponsored research 1996, $M	Industry-sponsored research in % of total FY96	Annual Research Budget 1991 , $M	Industry-sponsored research 1991, $M	Industry-sponsored research in % of total FY91
5	Total Budget $2M; patenting $500K	441.3	35.1	8.0	324.1	23.4	7.2
4	Total Budget: $2.2M. For patenting: $2M. License income $700K	395.5	19.6	5.0	280.1	14.1	5.0
10		328.0	20.0	6.1	238.0	4.5	1.9
11		250.0	22.3	8.9	181.0	17.6	9.7
8	Total budget: $4M; for patenting: $750K	218.0	4.0	1.8	115.0	2.7	2.3
6	Patenting budget: $400-500K. License income $200-300K	207.7	17.3	8.3	154.0	10.0	6.5
3	N.A.	165.0	21.5	13.0	N.A.	N.A.	N.A.
9	Patenting budget: $855K. License income $580K	146.0	16.4	11.2	82.3	1.0	1.2
13		144.1	13.2	9.2	87.2	2.8	3.2
1	Total budget: $320K; for patenting: $90K	140.6	5.4	3.9	106.2	16.4	15.4
7	Total budget $580K; for patenting: $150K	128.5	10.6	8.2	109.1	24.5	22.5
2	Total budget: $389K; for patenting: $154.2K; license income $136.5K)	64.4	4.1	6.4	66.0	5.1	7.8
12		13.5	2.7	20.3	10.2	1.6	15.3
Total		2642.6	192.3	7.3	1753.2	123.7	7.1

Table 6. Technology Transfer in U.S. Universities - Miscellaneous data

Data from interview material

University	Policy wrt exclusive vs. non-exclusive licensing (*)	Patent ownership if institutional non-interest (*)	Sharing of license income (net) (*)	Monitoring of royalty agreements (*)	Proposed success indicators (*)
1	Industry sponsors get option on exclusive license	Univ. owns patent but licenses it back to inventor	50 % inventor(s), 25 % OTT, 25 % mgmt center or school	Needs improvement.	Commercial use on the market. Local firms working w/ university. Faculty satisfaction.
2	No policy	Assigns ownership to inventor	<$50K: 60 % inventor, 15 % dept, 5 % college, 20 % univ. $50-100K: 40 % inventor, 25 % dept. 15 % college, 20 % univ. >$100K: 30% inventor, 30% dept., 20 % college, 20 % univ.	Annual review, annual billing. Termination in case of non-payment.	Still working on that.
3	No policy	If sponsored research: univ. owns IP but may assign it to inventor. If not sponsored, inventor owns. In both cases, income is shared.	4 basic distributions depending on how IP was created: Univ. 100%, inventor 0%; Univ. 0%, inventor 100%; 50/50; or 15/85. Univ. share is divided equally betw dept and univ. admin.	Licensees required to maintain records and make them available for annual audit.	Number of technologies brought to market. Service to faculty. Regional economic development. Number of spin-off companies. Financial result for univ.
4	No. Depends on circumstances	If govt. sponsored, rights are returned to govt. In other cases, OTT may license inventor.	15 % of gross revenue to support OTT. Then direct expenses are deducted. Net revenue: 33 % inventor, 33% dept., 33% school	Licensing associates and OTT accounting monitor and enforce royalty agreements.	Number of licences. New monies and royalties generated. High licensing rate of patents.
5	No, but follow guidelines for federal funding	Reassignment to inventor.	<$200K: 50% inventor, 25% dept., 25% mgmt center. $200-$2000K: 33.3% inventor, 33.3 % dept., 33.3% mgmt center. >$2000: 33.3% inventor, 66.7% mgmt center	Moving from manual to computerized monitoring and invoicing.	Royalty income. Number of patents and licenses. Degree of success of transfers (not only monetarily).
6	No policy	Reassignment to inventor. Income shared.	<$75K: 50% inventor; of the remainder after expenses 33.3% inventor, 25% univ., 52.7% dept. >$75K: after expenses, 33.3% inventor, 25% univ., 52.7% dept.	Starting to implement computer program to monitor license payments. Have begun terminating non-compliant licenses.	Service to faculty.
7	Usually exclusive licenses	Reassignment to inventor.	Non-medical: <$100K: 50% inventor, 10% dept. 30% school, 10% tech promotion. Non-medical >$100K: 40% inventor, 20% dept., 25% school, 5% tech promotion, 10% tech research. Medical <$100K: 50% inventor, 20% dept., 20% school, 10% tech promotion. Medical >$100K: inventor 40%, dept. 255, school 20%, tech promotion 5%, tech research 10%.	An administrator monitors via a computer program.	Level of overall activity: patent applications, license income, royalties.
8	Only exclusive licenses	Reassignment to inventor.	Inventor 50%. Of remainder, 25% dept., 75% general fund	Not effective. Companies usually contacts OTT, not vice versa.	Number of invention disclosures.
9	No policy	Licensed to inventor.	40% inventor, 20% inventor's research, 10% dept., 10% school, 20% univ. adm.	Finance person within OTT monitors agreements.	Activity level wrt number of disclosures. Restricted disclosure agreements, MTAs, license agreements, patent app., patents issued, lic. income, expenses reimbursed.

Table 7. Total Research Expenditure, Number of Licenses and Options, and Total License Income, FY 1996

Institutions	Total Research Expenditure	Cumulative Active Licenses and Options	Total license income
5	$441,300,000	142	$1,074,747
4	$395,464,378	903	$43,752,059
10	$328,000,000	94	$782,000
11	$250,000,000	218	$9,413,429
8	$218,000,000	N.A.	$3,900,000
6	$207,733,549	78	$1,096,700
3	$164,982,731	43	$7,135,262
9	$146,000,000	38	$2,580,000
13	$144,120,325	82	$2,939,965
1	$140,562,429	37	$543,397
7	$128,500,000	67	$640,288
2	$64,374,226	39	$2,207,682
12	$13,513,704	6	$874,262

Table 8. Descriptive Statistics n					
	N	Minimum	Maximum	Mean	Std. Deviation
PROGYEAR Year in which institution devoted 0,5 prof. FTE to technology transfer	13	1970	1992	1985	6
96PTTFTE Prof. FTEs in technology transfer office	13	1	7	3	2
96STTFTE Support staff FTEs in technology transfer office	13	1	11	3	3
96INDEXP Research expenditures: Industrial sources	13	$2,748,331	$35,100,000	$14,792,737	$9,381,410
96FEDEXP Research expenditures: Federal government sources	13	$7,610,439	$336,771,918	$154,084,230	$96,809,229
96TOTEXP Total research expenditures	13	$13,513,704	$441,300,000	$203,273,180	$124,043,626
96LCEXEC Licenses/options executed	13	1	136	29	36
96ACTLIC Cumulative active licenses	12	6	903	146	245
96LIRECD License income received	13	$543,397	$43,752,059	$5,918,445	$11,684,127
96LCGNLI Licenses/options generating licenses income	13	1	259	52	70
96LILIFE Licenses income received in life science	13	$206,486	$36,061,053	$4,564,069	$9,729,029
96LIPHYS Licenses income received in physical science	13	$0	$7,691,006	$1,354,377	$2,675,048
96EXPLGF Legal fees expended	13	$143,822	$2,306,000	$871,629	$685,974
96REIMLG Legal fees reimbursed	13	$0	$941,000	$363,126	$346,691
96INVDIS Invention disclosures received	13	22	300	90	76
96TPTAPP Total patent applications filed	13	4	130	45	40
96NPTAPP New patent applications filed	13	3	90	33	28
96USPTIS U.S. patents issued	13	5	56	20	16
96STRTUP Start-ups initiated	13	0	14	3	5
Valid N (listwise)	10				

Table 9. Descriptive Statistics N					
	N	Minimum	Maximum	Mean	Std. Deviation
PROGYEAR Year in which institution devoted 0,5 prof. FTE to technology transfer	120	1925	1997	1985	12
96PTTFTE Prof. FTEs in technology transfer office	130	0	60	3	6
96STTFTE Support staff FTEs in technology transfer office	130	0	41	2	4
96INDEXP Research expenditures: Industrial sources	130	$59,000	$115,497,000	$11,770,796	$14,447,371
96FEDEXP Research expenditures: Federal government sources	131	$1,423,348	$868,719,000	$94,029,233	$124,744,587
96TOTEXP Total research expenditures	131	$5,417,090	$1,517,738,000	$142,658,426	$180,334,731
96LCEXEC Licenses/options executed	128	0	137	17	25
96ACTLIC Cumulative active licenses	128	0	903	82	137
96LCEXSU Licenses executed to start-up companies	124	0	14	2	3
96LIRECD License income received	131	$0	$63,200,000	$2,787,929	$7,846,979
96LCGNLI Licenses/options generating licenses income	130	0	513	38	63
96LILIFE Licenses income received in life science	119	$0	$36,061,053	$1,631,929	$4,113,471
96LIPHYS Licenses income received in physical science	119	$0	$7,691,006	$402,168	$1,094,628
96EXPLGF Legal fees expended	127	$0	$17,968,000	$591,312	$1,681,113
96REIMLG Legal fees reimbursed	126	$0	$7,090,000	$226,724	$685,996
96INVDIS Invention disclosures received	131	0	670	62	80
96TPTAPP Total patent applications filed	130	0	325	30	40
96NPTAPP New patent applications filed	129	0	207	21	27
96USPTIS U.S. patents issued	131	0	159	14	19
96STRTUP Start-ups initiated	129	0	14	1	2
Valid N (listwise)	80				

Table 10. Correlation matrix N and n

Correlations on N

	PROGYEAR	96TOTEXP	96LCEXEC	96ACTLIC	96LIRECD	96LCGNLI	96INVDIS	96TPTAPP	96USPTIS	96STRTUP	96TOTFTE
PROGYEAR	1.000	-0.504	-0.641	-0.536	-0.378	-0.567	-0.559	-0.536	-0.594	-0.449	-0.463
96TOTEXP	-0.504	1.000	0.996	0.995	0.982	0.997	0.999	0.999	0.998	0.994	0.997
96LCEXEC	-0.641	0.996	1.000	0.998	0.984	0.998	0.997	0.997	0.997	0.995	0.993
96ACTLIC	-0.536	0.995	0.998	1.000	0.988	0.998	0.996	0.997	0.996	0.995	0.994
96LIRECD	-0.378	0.982	0.984	0.988	1.000	0.989	0.983	0.985	0.984	0.980	0.988
96LCGNLI	-0.567	0.997	0.998	0.998	0.989	1.000	0.997	0.998	0.998	0.993	0.997
96INVDIS	-0.559	0.999	0.997	0.996	0.983	0.997	1.000	0.999	0.998	0.995	0.996
96TPTAPP	-0.536	0.999	0.997	0.997	0.985	0.998	0.999	1.000	0.999	0.995	0.996
96USPTIS	-0.594	0.998	0.997	0.996	0.984	0.998	0.998	0.999	1.000	0.994	0.996
96STRTUP	-0.449	0.994	0.995	0.995	0.980	0.993	0.995	0.995	0.994	1.000	0.990
96TOTFTE	-0.463	0.997	0.993	0.994	0.988	0.997	0.996	0.996	0.996	0.990	1.000

Correlations on n

	PROGYEAR	96TOTEXP	96LCEXEC	96ACTLIC	96LIRECD	96LCGNLI	96INVDIS	96TPTAPP	96USPTIS	96STRTUP	96TOTFTE
PROGYEAR	1.000	-0.595	-0.819	-0.864	-0.734	-0.764	-0.599	-0.870	-0.723	-0.858	-0.670
96TOTEXP	-0.595	1.000	0.702	0.599	0.467	0.672	0.467	0.703	0.782	0.741	0.903
96LCEXEC	-0.819	0.702	1.000	0.980	0.930	0.991	0.362	0.760	0.770	0.801	0.810
96ACTLIC	-0.864	0.599	0.980	1.000	0.975	0.968	0.636	0.897	0.777	0.868	0.757
96LIRECD	-0.734	0.467	0.930	0.975	1.000	0.920	0.270	0.646	0.659	0.691	0.658
96LCGNLI	-0.764	0.672	0.991	0.968	0.920	1.000	0.255	0.690	0.717	0.723	0.790
96INVDIS	-0.599	0.467	0.362	0.636	0.270	0.255	1.000	0.827	0.631	0.784	0.344
96TPTAPP	-0.870	0.703	0.760	0.897	0.646	0.690	0.827	1.000	0.843	0.913	0.648
96USPTIS	-0.723	0.782	0.770	0.777	0.659	0.717	0.631	0.843	1.000	0.791	0.792
96STRTUP	-0.858	0.741	0.801	0.868	0.691	0.723	0.784	0.913	0.791	1.000	0.759
96TOTFTE	-0.670	0.903	0.810	0.757	0.658	0.790	0.344	0.648	0.792	0.759	1.000

Correlations are significant at the 0.05 level (2-tailed).
Correlations was estimated using Pearson Correlation

Table 11. Regression on N

Y	b_1*X_1 program year	b_2*X_2 total exp.	b_3*X_3 Staff/ FTE	b_4*X_4 Inv.dis	b_5*X_5 total patent app.	b_6*X_6 new patent app.	b_7*X_7 US patent issued	b_8*X_8 Cum. licenses	R2 and R2 adj. *= sig. t-values
Inv. dis.	-.964 β_1=-.139	2.230 E-07 β_2=.502	3.003 β_3=.361						.839 .835 *
Total patent	-.347 β_1=-.100	1.313 E-07 β_2=.593	1.206 β_3=.291						.839 .835 *
Total patent				.468					.888 .888 *
New patent				.306					.847 .846 *
Patent issued					.436				.812 .811 *
Patent issued						.707 (t-1)			.807 .805 *
License							1.234 (t-1)		.702 .699 *
Cum. licenses					2.906				.700 .697 *
License inc.								45590	.622 .619 *
Start-ups	-3.775 E-02 β_1=-.192	5.428 E-09 β_2=.429	2.157 E-02 β_3=.091 not sig. t –value						.398 .382 *

Table 12. Regression on n

Y	$b_1{*}X_1$ program year	$b_2{*}X_2$ total exp.	$b_3{*}X_3$ Staff/ FTE	$b_4{*}X_4$ Inv.dis	$b_5{*}X_5$ total patent app.	$b_6{*}X_6$ new patent app.	b_7Xx_7 US patent issued	$b_8{*}X_8$ Cum. licenses	R2 and R2 adj. *= sig. t-values
Inv. dis.	-8.469 β_1=-.685	5.397 E-07 β_2=.886	-13.733 β_3=-.915 not sig. t-value						.509 .345 *
Total patent	-5.229 β_1=-.804	2.188 E-07 β_2=.683	-4.005 β_3=-.507						.851 .801 *
Total patent				.435					.684 .655 *
New patent				.316					.739 .715 *
Patent issued					.337				.711 .685 *
Patent issued						.547 (t-1)			.410 .357 *
License							1.688 (t-1)		.818 .802 *
Cum. licenses					6.415				.805 785 *
License inc.								48461	.950 .945 *
Start-ups	-.482 β_1=-.641	1.254 E-08 β_2=.338	2.171 E-02 β_3=.024 not sig. t - value						.819 .759 *

Appendix A.

TECHNOLOGY TRANSFER SURVEY QUESTIONNAIRE

Date of interview ________________

Name of institution _______________________________

Name and title of person interviewed ____

Organization

How is the office of technology transfer (OTT) organized?
How does it fit into the university structure
- administratively?
- legally?

Is there more than one technology transfer office? Are there branch offices with delegated responsibilities within the university structure?

How does the university manage the risk exposure associated with technology transfer? Where does the requisite legal expertise reside? Is there a legal officer within OTT to manage that responsibility?

What is the total annual budget for:
Technology licensing?
Patent expenses?
How is this budget divided between units (if there is more than one OTT unit)?

How does the university organize the commercialization process with respect to:
Licensing?
Start-up or spin-off?

Is the OTT actively involved in facilitating technical, entrepreneurial and financial support? If so, what are the institutional arrangements?

What departments in the two or three most active units (schools, management centers, etc.) does the technology transfer office most frequently serve?

Approximately, how many faculty members do these departments have?

Process

Who initiates the technology transfer process?

In general, does the researcher know where and to whom to turn?

What are the procedures for non-disclosure or confidentiality agreements?
Please describe the process in a typical case.
Who are the people involved in the negotiation procedure, and what level of authority or autonomy do they represent?
Duration of the process?

What are the procedures for material transfer agreements (MTA's)?
Please describe the process in a typical case.
Who are the people involved in the negotiation procedure, and what level of authority or autonomy do they represent?
Duration of the process?

What are the procedures for licensing agreements?
Please describe the process in a typical case.
Who are the people involved in the negotiation procedure, and what level of authority or autonomy do they represent?
Duration of the process?

What are the procedures for start-ups?
Please describe the process in a typical case.
Who are the people involved in the negotiation procedure, and what level of authority or autonomy do they represent?
Duration of the process?

Who initiates patent applications?
The technology transfer office
The researcher
Other

Is the stance of the university one of passively or actively facilitating patenting?

How many patent applications do you handle each year?
More than the technology transfer office can handle or too few?
How do you determine what is going to be patented?
What are the main constraints, personnel, budget, other?

What are the major fields or disciplines generating patents? Are they representative of the research strengths of the university?

What is the number of patents generating income exceeding $100,000 annually?

What success indicators do you use to evaluate the effectiveness of your OTT?

What are the accounting problems involved in funding the technology transfer structure and distributing the proceeds between the university/management centers/departments?

How are royalty agreements monitored and enforced?

Has the industry sponsored research increased over the years?
If yes, how much has it increased?
What mechanisms are behind this development and how did it come about?
How does the university feel about industry sponsored research? Is it important?
What is the impact on technology transfer?

What are the linkages between industry-sponsored research on one hand and patenting and licensing activities on the other?

Is there an institutional policy with regard to exclusive vs. nonexclusive licensing based on source of funding?

What is the university policy with respect to patent ownership after review and declaration of institutional non-interest? How is patent ownership allocated between the researcher (patent author), the university, and other entities?

How is the license income shared between different players or units (entities)?

Do the procedures for research agreements differ with respect to the source of funding, i.e., industry-sponsored research versus government funding? If so, how do they differ?

In the case of industry-sponsored research, what are your policies regarding exclusive/nonexclusive licensing and sublicensing?

Personnel

What is the size of the staff of the technology transfer office? At the university level? At other levels?
How many are professionals and how many are supporting staff (FTEs)?
Are they working part time or full time?

What are the areas of expertise of the professional staff?
- Basic science
- Legal
- Business/management
- Other

Are there any additional needs for expertise in the technology transfer office?
If yes, What kind of expertise are you looking for?

Other

Is there any particular model for technology transfer that you think should be emulated (especially as it may fit your institution)?

What are the sources of local support for technology transfer in your university community?