Managing the University Technology Licensing Process: Findings from Case Studies

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University technology licensing offices ("TLOs") face a dynamic environment in which the number of technology disclosures is rapidly increasing while the available resources for licensing technologies do not keep pace. Adopting new, strategic plans for licensing is therefore vital. This paper develops an analytical framework for the licensing process. It then presents evidence from 14 case studies and numerous interviews. We conclude that while TLOs have vastly improved since 1980, they have an opportunity to generate significant additional public value. Drawing on the analytic framework and case studies, the paper concludes with recommendations to help TLOs continue to improve their licensing strategies in this challenging environment.

I. INTRODUCTION

The number of university technology licensing offices has increased tremendously over the past seventeen years. One important cause of this growth is the 1980 Public Law 96-517 (the "Bayh-Dole" Act), which allowed universities to receive and assign intellectual property ownership rights for inventions arising from federally funded research. Consequently, university patenting and licensing activities have steadily increased since the early 1980s. For example, for a five-year recurrent sample of US universities, invention disclosures increased 29 percent over the 1991 to 1995 period (1). In addition, the Association

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of University Technology Managers (AUTM), the national association of licensing officers, has grown from less than 100 to over 1,600 members since 1980 (2). Many research universities now have licensing offices that vary in budget size, policy, and even core mission. While university TLOs have varying mission statements, many TLOs seek timely dissemination of technology to further the public good. Generally, TLOs' emphasis is *not* to maximize collection of royalties, but rather to maximize the societal benefit of technologies. In this way, university TLOs differ markedly from their private sector, profit-driven counterparts.

Given resource constraints in evaluating and licensing new technologies, university TLOs must adopt strategic plans to avoid missed opportunity in promising and potentially important technologies. This task is complicated by the inherent market and technical uncertainty typically associated with university innovations. Furthermore, the ease of university technology licensing depends on the institutional culture within which a TLO operates. In this study, we focus on those technologies TLOs decide to "pursue" (by filing for a patent) but which remain unlicensed. More specifically, we target promising technologies for which the market has failed to pair willing buyers and sellers. In addition, we address technologies that are not sufficiently developed to be of interest to companies or potential investors. While this second set of unlicensed, "embryonic," technologies does not necessarily constitute lost opportunity from society's perspective, we believe universities can pursue strategies to increase the probability of licensing them.

We address two primary questions in this study: (1) Are TLOs committing to a "good" portion of their technologies? (2) How successful are TLOs in getting committed technologies licensed?

There is little we could recommend to reduce the risk inherent to university technologies. Similarly, we cannot change university environments. This study is intended instead to offer

recommendations, based on case study evidence, to license a greater share of university technologies *given* the presence of uncertain technologies and unique academic cultural environments.

We developed fourteen case studies, drawn principally from technology originating from major east and west coast universities. These case studies encompass both successfully *and* unsuccessfully licensed technologies. For each case, we interviewed the licensee (for the successfully licensed technologies), inventor(s) when possible, the technology licensing officer associated with the license, and others (e.g., venture capitalists) who played substantial roles. In some cases in which a technology was not licensed, we were able to interview the people who declined to license the technology. The following matrix categorizes our case studies:

Case Studies	*Biotechnology*	*Non-Biotechnology*
Successfully Licensed	3 cases	6 cases
Unlicensed	2 cases	3 cases

While our case study evidence suffers the inherent limitation of case and interview-based research, the technology licensing officers with whom we worked suggested that our case studies and industry interviews offer a reasonably representative sample of their technologies and clients. Our interview base probably reflects more start-ups and higher potential technologies than the norm, however.

II. ANALYTICS OF TECHNOLOGY LICENSING

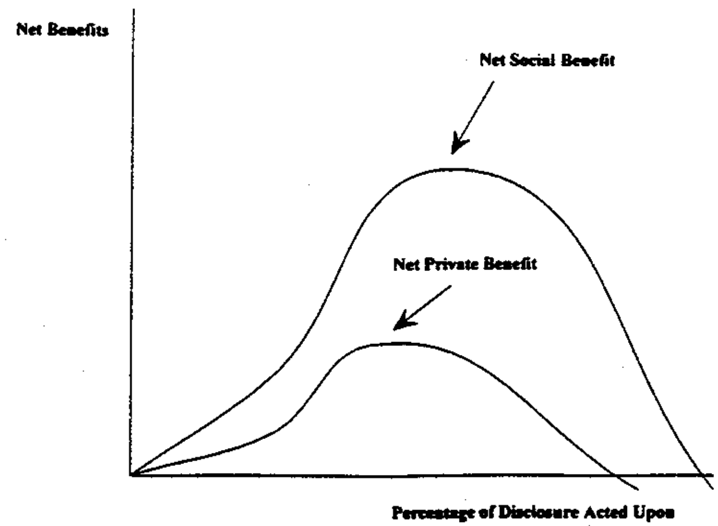
This section analyzes the two primary licensing functions. We refer to these functions, committing to and licensing technologies, as the licensing officer's "search process." TLOs face the problem of maximizing net social value through their search process, subject to resource constraints. Underlying the search process is an implicit TLO policy regarding the number of technology disclosures to pursue. For example, if a TLO has historically decided to file patents on 50% of all disclosures, a licensing officer in that TLO might base her commitment decision on whether the current disclosure is likely to be in the top half of disclosures received this year. We introduce and analyze a "commitment spectrum" framework to explore the proportion of disclosures for which TLOs should seek patents. For the ensuing search process, we define concepts underlying a rational search strategy and briefly consider obstacles and other factors that might inhibit societal benefits. While recognizing the concept of maximizing net social value is an unattainable abstraction, we believe that a brief discussion of optimal social benefit will offer a useful benchmark with which to analyze current TLO performance. We begin by discussing the TLO commitment policy.

A. The Commitment Decision: How Many Technologies to Pursue?

How aggressive should TLOs be in selecting a *portfolio* of technologies to license? We now focus on policy decisions that guide the share of technology disclosures to which TLOs should commit. These policies establish the context in which licensing officers decide to accept or reject specific disclosures.

The following schematic depicts the relationship we expect between percentage of disclosures acted upon, or "pursued," (on the horizontal axis) and net societal and private returns (on the vertical axis). If the expected societal benefits (consumer and inventor benefits, royalties, and royalty-sponsored research) of pursuing a technology exceed its costs (patenting, licensing, and development costs), then the technology offers a positive net societal return. Net private return, which measures only the costs and benefits realized by a private organization, is usually a subset of net societal return. We refer to this graph as the "commitment spectrum." Universities will differ, however, in their location along the spectrum at which they maximize social benefit.

Figure 1: TLO Commitment Spectrum



Most venture capitalists (VCs) and for-profit licensing organizations are relatively conservative in pursuing technologies. VCs choose technologies that they build into start-up companies, and hope these start-ups will go public. At this position on the spectrum, only a comparatively small number of technologies will meet the stringent criteria of technological and business potential that venture capitalists impose. These private sector organizations have a clear mission of maximizing private returns, and will probably forego significant societal benefit by not taking more risks.

Where should university TLOs place themselves on the spectrum? If a TLO's mission is to maximize net social benefit, the TLO should place itself to the right of private licensing offices. By choosing this strategy, TLOs hope to maximize the probability of committing to technologies that would be net beneficial to society. A less tangible benefit of pursuing more technology commitments is the goodwill created with a university's inventors, often an important component of a TLO's authorizing environment.

There is a cost to moving too far to the right on the spectrum, however. In addition to increasing actual patenting costs, pursuing too many technologies might cause promising technologies to remain unlicensed, as they compete with a greater number of "unworthwhile" technologies for scarce TLO marketing resources. Furthermore, the stigma of a non-discriminating university TLO could damage the value and reputation of all technologies originating from that university. At some point, therefore, the cost of moving too far to the right on the spectrum, with too few resources to adequately devote to such a move, begins to reduce returns to additional commitments.

Maximizing social returns through placement on the commitment spectrum is, of course, uncertain in practice. To a short-sighted university administrator, the fact that a smaller fraction of committed technologies remains unlicensed may be taken as a sign of a successful TLO. This is a fallacious view, however. From a societal standpoint, if a TLO is licensing nearly all of its "committed" technologies, it should probably be pursuing *more* patents. The inevitable cost of trying to commercialize earlier-stage technologies is taking risks on some technologies that may or may not be, on balance, beneficial.

B. The Search Process

The licensing officer's search process includes committing to technologies and then attempting to license them. This section categorizes a technology's "size" and its stage of development, two important factors in a technology's value.

These two components also influence a technology's likely licensing path.

Size of a Technology. Determinants of a technology's size include magnitude of advantage over current and other new methods; size of potential market; cost-of- and time-to-development; patentability; and "appropriability" (the ability of a private firm to protect for itself profits from an innovation).

The sizes are:

- *Large*: Major innovations, for obvious ("blockbusters") or less foreseeable ("disruptive" technologies) markets.
- *Medium*: Innovations significant enough to support a start-up company or a new line of products for an existing company.
- *Small*: Innovations probably too small to support a start-up, but adequate for a product in an existing firm.
- *Embryonic/Uncertain*: Innovations with potential commercial feasibility, but with concepts as yet unproven.
- *Unworthy*: Innovations with little or no commercial potential.

Stage of Development. Stage is another component of potential technology value, and it describes where a technology stands on the commercialization path, ranging from theory-only to refined prototype. Stage includes dimensions of technical and market feasibility/risk.

A TLO's decision to pursue a specific technology will be affected by the TLO's commitment policy, which incorporates the TLO's historical percentages of disclosures accepted, the TLO's expected available resources, and the level of risk that the licensing office can undertake within its university environment. The decision will also involve the licensing officer's assessment of the technical and business merits of specific disclosures, taking into account the size and stage of development of the advances.

Licensing Paths. There are five paths for committed technologies in the licensing market:

- License to established companies
- License to start-up companies
- Develop through "ripening" mechanisms
- Out-source to private licensing organizations
- Remain unlicensed ("sit on the shelf")

Table 1: Expected Licensing Path Scheme

If a technology is this size:

Then this is the expected licensing path depending on its stage of development:		Large	Medium	Small	Embryonic
	Established Firm	x	x	x	
	Startup	x	x	x	
	"Ripen"			x	x
	Out-source				x
	"Sit on Shelf"				x

C. Potential Market Failures

There might be failures in the licensing market, however, which prevent a technology from progressing along its projected licensing path. In the next section, we examine case study evidence on failures, both internal and external to university TLOs, that drive a wedge between practice and theory.

III. CASE STUDY AND INTERVIEW EVIDENCE

We now present our findings regarding the licensing of university technologies. We first discuss findings from our case studies, with particular reference to start-ups. Table 2 is an overview of the cases, detailing reasons for their successful (or unsuccessful) licensing. Specifically, we present evidence on two fronts: market failure and successful and unsuccessful marketing strategies. In section three, we discuss current university positioning along the commitment spectrum. The section concludes with two overarching points. First, our evidence suggests that many unlicensed technologies may be worthy of

licensing and development. Second, an important driver of licensing success in our sample was the amount of protection afforded by patents in a given industry.

A. Case Studies Evidence

Of the five technologies in our sample that went unlicensed, one has proven not to have commercial merit, while insufficient proof of concept is the primary reason three of the other four remain unlicensed. The most important factors contributing to the successful technology transfers in our case studies, in order of importance, were effort on the part of entrepreneurs, the value (size and stage) of technologies, and financing issues.

The majority of our case studies ultimately resulted in the creation of start-up companies. Start-ups, while by no means the most common path through which university technologies get licensed, fill a critical gap in technological dissemination. As Table 2 shows, almost half of the licensed technologies in our sample would likely have remained unlicensed had a start-up company *not* licensed them.

1. Entrepreneurial Spirit

Individuals who took the initiative to organize a business around a technology were overwhelmingly the single most important factor for technologies successfully licensed to start-up firms. These entrepreneurs ranged from the inventors themselves to individuals who went to the TLO in search of a technology in which to invest. We illustrate by discussing one entrepreneur's journey through two universities' TLOs before settling on a technology that would likely have otherwise remained on the licensing office shelf.

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Case Study: An Equipment Start-up Company

A motivated entrepreneur approached one university's TLO in 1988-89 in search of university technologies to license. A neuroscientist at the university had recently created a device that could accurately measure ion channel flows. Though the entrepreneur took an option on this technology, he was unable to secure financing for a start-up.

Still determined to license a university technology, the entrepreneur walked into another university's TLO. There, a licensing officer introduced him to a potential product, an instrument that interfaces high performance liquid chromatography with Fourier transform infrared analysis. A scientist at this university had built in his chemistry lab a prototype of the device that met regulatory requirements. A few large firms had expressed interest in the technology but ultimately felt that it did not fit their existing product lines.

The entrepreneur took an option on the technology, conducted a market study, researched the underlying issues, decided to license the technology, and formed a start-up company in December 1990. The entrepreneur thought that the existing prototype had "too many knobs" to be readily commercialized, reasoning that it would take too long to train a lab technician to use the device. The entrepreneur built another prototype of the machine and the firm had its first sale soon-thereafter, in March 1991.

Through one of their occasional telephone conversations, the entrepreneur learned from the chemistry professor that the lab had a new technology that would complement the original instrument. The scientist was about to present a paper describing the new technology at a conference in 1994. At the urging of the entrepreneur, the university's TLO consulted patent counsel. Counsel advised the university to file another patent application because the original patent did not entirely cover the new technology. The entrepreneur's start-up company subsequently licensed the complementary technology.

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Table 2 CASE STUDIES - Successfully Licensed

CASE NUMBER	*Primary Reason Licensed*	*Primary Reason Not Licensed to Established Co.*	*Secondary Reasons Licensed*	*"Size" of Technology*	*Stage of Technical Development*	*Licensee*	*Source of Financing*	*Who Found Financing*	*Additional Licenses*
Biotech - Licensed									
1	CEO Relations with researcher	N/A (licensed to established company)	The Technology is a Sure Winner	Large	Embryonic – concept proven	Estab-lished company	Internal	CEO	Many
2	Licensing officer/VC	Venture Cap. (VC) Interest; VC Preemption	Technology has Large Potential	Large	Embryonic – concept proven	Startup	Venture Capital	Licensing Officer	Many
3	Licensing Officer/VC	Entrepreneur Preemption	Biotech Startups Trend	Medium to Large	Embryonic – concept proven	Startup	Venture Capital	Licensing Officer	Not yet
Non-Biotech - Licensed									
4	Entrepreneur	Too Small, Conservative Industry	Prototype; Equity Policy	Small	Preliminary Prototype	Startup	Friends	Entrepreneur	No
5	Inventor, TLO	Too embryonic; Disrupting	Silicon Valley; Interest in the Technology	Potentially Large	Preliminary Prototype	Startup	Self; VC; Silicon V.; ARPA	Inventor; Silicon Valley	Aggressively Looking
6	Co-Inventor	Co-Inventor Preemption	Self-financed	Medium	Concept Proven	Startup	Self, SBIR	Co-Inventor	Interested
7	Entrepreneur	Too Small	Equity Policy; Prototype	Small to Medium	Preliminary Prototype	Startup	Friends	Entrepreneur, VC	Yes
8	Co-Inventor; Entrepreneur	Industry Growing Too Fast	Minimal Financing Requirements; Prototype; Equity Policy	Small to Medium	Prototype	Startup	Self	Co-Inventor/ Entrepreneur	Interested
9	Inventor; Silicon Valley	Original Licensee went Bankrupt	Great Interest in the Technology	Potentially Large	Prototype	Startup	VC; Silicon Valley	Inventor; Silicon V.	Interested

Table 2 (continued) CASE STUDIES - Unlicensed

CASE NUMBER	*Primary Reason Will Be Licensed**	*Primary Reason for Unlicensed*	*Secondary Reasons Not Licensed*	*"Size" of Technology*	*Stage of Technical Development*	*Prospective Licensee*	*Likely Source of Financing*	*Who Found Financing*	*Additional Licenses*
Biotech - Unlicensed									
10	Inventor; Substantial Proof of Concept	Insufficient Proof of Concept		Large	Embryonic – concept proven	Startup	Self, VC, Company Partners	Inventor	Maybe
11		Insufficient Proof of Concept	Disrupting Technology; Confused Licensing Strategy	Unclear, Disruptive	Embryonic – no proof of concept				
Non-Biotech - Unlicensed									
12		Insufficient Proof of Concept	Poor Licensing Strategy; Patent uncertainty; Regulatory cost uncertainty; Passive inventor	Potentially Large					
13		Cost	Enabling only	Potentially Medium					
14	TLO, Inventor	Industry Structure	Competing Alternatives	Medium		Established Company	Internal		Probably Not

* Primary reason we believe these technologies will be licensed (both bolded entries are likely to be licensed imminently).

2. Value of Technologies - Stage in Development and Size of Technology

Embryonic stage of development is the primary reason three of our five unlicensed technologies remain unlicensed. Having a prototype, even a preliminary one, is especially important in the non-biotechnology start-up world. Though licensees of biotechnology demand proof of concept at an earlier stage of development than in other sectors, biotech licensees like to see the clear advantage and reliability of an advance. Probably for these reasons, a potentially disruptive biotechnology in our sample has not yet been licensed. For this technology, even having an eminent biology professor as a scientific champion has proven insufficient in successfully licensing the innovation. The diversity of "sizes" across our cases suggests that size is not the sole determinant of licensing success, though size probably influences the preferred licensing path for a given technology.

3. Equity/Financing Issues

Our cases suggest that financing issues are a key determinant of the probability of licensing success through start-ups. Financing issues, including university equity policies and up-front licensing fees, can determine whether a start-up entrepreneur licenses a technology. In addition, contacts in the venture capital community can give TLOs a competitive advantage in licensing. Equity policies are a critical component of any start-up strategy. Most of our sample start-up companies, especially in the physical sciences, would not have considered a start-up without the ability to offer equity in lieu of up-front fees. In addition, structuring high up-front license payments can sometimes be fatal. Most start-ups in the sample stressed the importance of minimizing these up-front burdens.

4. Other Factors of Licensing Success

First, granting exclusive licenses is an additional important factor in successfully licensing university technology; it was cited as critical in virtually all of our cases. Many of our case study entrepreneurs, regardless of the size of the specific technology in question, would not have licensed their technologies without an exclusive license. The threat of direct competition in a niche market is usually too daunting for the licensee. Therefore, exclusive licenses are often necessary economic incentives for would-be licensees (3).

This is not always true, however. One of the important factors contributing to the enormous success of the Cohen-Boyer patents, for instance, was the non-exclusive licensing strategy taken by Niels Reimers and the Stanford TLO (4). The Polymerase Chain Reaction advance, a process that allows rapid DNA synthesis, was licensed by Cetus Corporation under a very successful strategy that included both exclusive and non-exclusive components (5).

Second, having an established network of related technology firms and a well-developed, start-up support infrastructure in close geographic proximity can sway a potential start-up entrepreneur to license. Boston's Route 128 and Northern California's Silicon Valley have a "critical mass" of technology firms in which a wealth of experts, complementary materials, and social capital are available in a centralized location (6).

A third factor contributing to licensing success is the need for patent protection in order to assure private entities a reasonable chance of capturing profits from their development efforts and expenses. Withdrawing the risk that other entities will duplicate the product makes

the technology more valuable to a potential licensee. These concerns are also important to established firms.

B. Licensing to Established Companies: Interviews and Case Evidence

TLOs license most of their patents to established firms. However, the majority of licensing failures, both in our cases and as reported by our interviewees, were in building ties to existing companies. Through interviews with private sector directors of technology licensing and heads of research and development, we learned about the process of licensing at established firms and about TLO marketing strategies these firms find effective (and ineffective). Following a brief discussion of the importance of university-generated technology, we present findings regarding actual sources of market failure. We then synthesize from our findings a collection of successful and unsuccessful marketing strategies.

Without exception, the people we interviewed expressed their belief that university-originated technologies are important to the competitive advantage of their firms. Even research directors from companies that license only through sponsored research agreements spoke of the importance of university-generated technologies. Given this relationship between university research and industry competitive advantage, we might expect the licensing market for these technologies to work efficiently.

1. Evidence Regarding Internal Sources of Market Failure: TLOs

(a) *Inappropriate Incentives to Licensing Officers*. Several of our experts suggested that incentives for licensing officers are less than ideal. These experts suggest that incentives may encourage officers to pursue short-run royalty returns, to avoid up-front, unremunerated costs, and to lower numbers of committed technologies in their portfolios in order to increase ratios of successfully licensed to total committed technologies. These incentives thus shift TLOs too far to the left on the commitment spectrum at the expense of long-term TLO, university, and societal benefit.

(b) *Licensing Officers Unable to Specialize.* Our cases and interviews suggest that licensing officers must invest significant amounts of time learning about unfamiliar products, and technologies. Given the importance (suggested by our cases) of establishing personal relationships with target licensees, larger-scale licensing offices seem attractive. Several of our interviewees also suggest that there is a critical mass of university research activity required before a TLO can become minimally efficient. Smaller universities (as measured by size of research budgets) might be better off combining licensing office resources, or at least, resorting to the outsourcing alternative.

Outsourcing seems to offer limited value to any university that has committed reasonable levels of resources to licensing. The one circumstance under which outsourcing *does* make sense is for universities that do not maintain significant internal licensing office resources. For example, one east coast university has one licensing officer who is responsible for managing both the university's 80 new annual disclosures and the school's portfolio of existing licenses.

(c) *Licensing Officers Holding onto Technologies.* Several of our experts reported that TLOs sometimes stay with a technology too long, for example, to keep an important professor satisfied.

2. Evidence Regarding External Sources of Failure: Established Companies

(a) *Imperfect Information.* Our cases suggest that licensing officers generally find the right sets of target companies. This effort is easier when the inventor is knowledgeable of target companies, and more difficult and time-consuming when the licensing officer must generate the targets on her own. Many of our company interviewees, however, reported their desire for more proactive outreach on the part of TLOs beyond "cold letters."

(b) *Private Sector Organizational Failures.* This failure hypothesizes inappropriate firm organization as an obstacle to the fair assessment of technologies. Our experts and cases suggest that this category, from ineffectual gatekeepers to the "not invented here syndrome" (unwillingness to consider technologies generated outside their company) is not generally a source of failure in licensing markets. Furthermore, in cases when TLO marketing letters were sent to the wrong people within a firm, the letters generally made their way to the desks of appropriate company officials.

(c) *Disrupting Technologies.* The Haloid-Xerography technology is one of the most recognizable examples of a high-potential technology under-appreciated and shunned by investors. Two of our case studies may have experienced this phenomenon.

(d) *Embryonic Technologies.* Several of our case studies were of technologies that either were not licensed or took years to license, principally because the technologies were at a stage too early to interest the private sector. However, several of our cases also suggest that there is sometimes little distance separating early stage from licensable technologies. Researchers in two cases suggest that an extra six months or year of funding and effort could be enough to raise significantly the licensing potential of their technologies. (As noted by one experienced technology licensing officer, however, inventors often underestimate the resources and time needed to establish proof of concept.) Several other cases illustrate the potential benefits of ripening mechanisms. These technologies may still be years away from market, but additional development effort can sometimes be sufficient to convince the private sector to invest.

There are several organizations that ripen technologies. These organizations have succeeded in bridging the gap between basic research and commercializable development. One executive we interviewed from such an organization commented that his group would be interested in closer ties with universities, suggesting a viable market to ripen technologies.

We conclude this section noting that our evidence suggests two pathways that mitigate market failure problems. First, if companies already have significant knowledge regarding a research project, they are much more likely to consider licensing the advances generated by that research. Usually, companies gain such knowledge when they have entered into sponsored research agreements with a university research lab. The other pathway for such knowledge is through personal ties to inventors. In such cases, as long as conflict of interest and intellectual property issues have been well thought out in advance, the licensing process usually proceeds smoothly.

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Case Study: Fire Ant Repellent

A professor of parasitology at a university characterized a tick secretion that he believed repelled fire ants by disrupting their social organization and communication abilities. A strong advantage of this technology, if it proves effective in repelling fire ants, is its environmentally-safe attribute. Field tests on the repellent have not yet been conducted, however, and the technology has not been licensed by the university's TLO despite two years of effort. A patent has recently issued on the advance.

In early 1994, the university's technology licensing officer sent letters to a group of (insecticide) companies she thought would be interested in licensing the technology. Several signed non-disclosure agreements to get more details on the technology. One of these firms was a large chemical company. The marketing letter from the university eventually reached the gatekeeper, the technology acquisition officer for the firm. The technology fit in the firm's commercial arena, but did not address a product concept of priority to the company. A third stage of the assessment would have judged the technical merits by conducting tests on the technology.

A second insecticide firm also expressed interest in the technology. The head of research at the firm believed the technology had potential. He knew that the demand for the environmentally-safe product would be high, and believed his company should explore the technical feasibility and development costs of the innovation. The company had just changed ownership, however, and the new top management was re-evaluating its priorities on development projects. The executives ultimately rejected the fire ant repellent technology because they did not want to commit to long-term technologies. In addition, the technology might have required registration with the US Environmental Protection Agency, a costly and time-consuming process.

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We do not observe evidence of our theorized market failures in licensing to either insecticide company. Both directors of technology acknowledged the importance of university-originated technologies to their firms. In particular, the internal organization of these firms did not prevent a fair assessment of the technology.

3. Successful Marketing Strategies

Having presented evidence regarding actual sources of market failure, we now synthesize the findings into successful and unsuccessful strategies for marketing technologies.

Our interviewees and case evidence suggest two strategies that seem to improve the odds of successful technology transfer to established firms. They are: networking with "captive" current licensees (firms that already license from TLOs) and adopting customer-driven approaches to existing companies.

Captive licensees from our case studies appear to be a resource underutilized by licensing officers, especially as sources of leads and suggestions for their industries. These licensees unanimously reported willingness to provide such information. Existing licensees are also potential "repeat" customers who are interested in licensing additional technologies. Table 2 highlights the extent of captive licensee interest among our sample cases by showing the number of additional licenses taken by each licensee. Captive licensees are also interested in networking opportunities among themselves.

A second successful strategy is adopting a customer-driven approach to existing companies. Our non-captive interviewees suggest that several factors are critical to catching the attention of their companies: establishing and maintaining personal contacts in industry; on-site

visits to firms; standing offers to industrial research and development leaders to visit the university and its research labs; and frequent personal follow-ups with target companies. Even if a particular technology is not licensed immediately through this strategy, these efforts may allow licensing officers to establish more contacts and spread information regarding the university's research. Under this strategy, the fewer internal resources a TLO has, the more it should think about how and where to concentrate its personal contact with industry.

4. An Unsuccessful Marketing Strategy

The majority of our interviewees from well-established companies are deluged with technology licensing opportunities. The companies in our sample have found little or no value in technologies marketed through the mail by TLOs. These companies typically have better understood, better focused (for their needs), more strongly-championed internal research and development projects. It is generally not worth the effort for companies to devote resources to consider all of these university-generated advances. Thus, TLO marketing letters might end up on the desks of the right people within companies, but those people often bury the letters at the bottom of their "to-do" piles.

We have thus found that "shotgunning," or casting a wide, untargeted net in search of a licensee is generally not effective. University TLOs that pursue shotgunning may also tend to spread their resources too thin, leading to inadequate research and understanding of the technological needs of established companies.

When a shotgunning strategy is used, licensing officers run the risk that their letters will not be read. There is a greater risk with untargeted mailings, though. In response to the flow of indiscriminate one page descriptions or comprehensive lists advertising university technologies, some technological gatekeepers have developed a belief that all technologies advertised through the mail are "bottom of the barrel" technologies. Sending advertisements of marginal or irrelevant technologies to a company contributes to a technology director's negative impression of TLOs sending untargeted mailings. Our research suggests that focused research and networking may result in better targeting of appropriate companies and better knowledge of market demand.

C. University Policies and TLO Positioning

In this section, we discuss TLO positioning on their "commitment spectrum" and its impact on societal value creation. Our discussion is based on our observations and the insights of the participants we interviewed (sixteen current and former licensing officers and two university administrators).

Where are Universities on the "Commitment Spectrum," and Where Should They Be?

Licensing industry participants and observers all agree that TLOs have improved significantly since the passage of Bayh-Dole. We also received a strong sense from a majority of our established company and licensing experts that there is much room for improvement in the licensing world.

We did not find statistics, for the most part, that measure TLO performance or even where the TLOs lie on the commitment spectrum. Most TLOs do not publish statistics that truly describe their licensing performance, though there are several notable exceptions. Royalty collection is widely cited, but we believe, a very misleading measure of performance in generating societal benefit. More accurate

would be statistics on invention disclosures, number of technologies pursued, and number actually licensed. Judging TLO performance from these statistics can be difficult as well, because a low fraction of technologies licensed to technologies pursued does not necessarily imply a poorly managed licensing process—a TLO in this situation may be pursuing earlier-stage technology that it feels will (eventually) generate net benefits to society.

D. General Observations

1. Serendipity

Our evidence suggests that there are two almost serendipitous conditions under which the role of the licensing officer is made easier. First are those cases in which entrepreneurs take on the responsibility for funding and developing technologies. Second are those cases in which the eventual licensee has a pre-existing relationship with the inventor. These cases suggest that there might be benefit to TLO efforts to enhance the conditions that generate such occurrences: for example, by sponsoring "open houses" on technology and financing for inventors, venture capitalists, and entrepreneurs.

2. Industrial Sectors, the Power of Patents, and Licensing

The second of our general observations is that many factors and characteristics can drive industry attitudes toward universities and the licensing process. However, our cases and interviews suggest that the underlying economics of patents, and of firms' abilities to capture profits deriving from their investments, is the most influential factor in determining industrial sector attitudes toward licensing. The greater the power of patents to protect profitability in an industrial sector, the more interested that sector is likely to be in a license, and the greater is the likelihood that universities will successfully license to that sector.

Of the sectors represented in our case studies, the biotech and high temperature superconducting companies were the most attentive to university-generated technologies. Interviewees and companies from these sectors cite two motivations for their interest. First is the strength of patent protection. Second is the fact that technologies being created in universities are particularly important sources of competitive advantage for these companies. Patents hold minimal importance for our interviewees in the process-driven semiconductor industry and can be easily circumvented according to our interviewees in the electronics industry. One eminent chemistry professor remarked that chemically-based materials companies with which he interacts are simply not economically compelled to reserve the rights to a chance at some big new advance. Consequently, these firms are much more reluctant to work through conflicting interests with universities and TLOs or to pay royalties.

These observations fit well with the research of Scherer (7) and Levin et al. (8), who found, respectively, that the power of patents varies among industries and that patents were rated as most powerful in the drug-related pharmaceutical and biotech industries.

3. The Biotech Sector

University-generated biotechnologies are licensed, on average, at a more embryonic state than other technologies. The reason for this appears to be two-fold. First, as Dr. Joseph Davie of Biogen (Cambridge, MA) says: "Probably more than half of the products in biotech as a whole came from discoveries in university laboratories" (9). Though industry devotes enormous budgets to R&D, the funds are spent *developing* technologies often created in universities. It therefore pays for biotech firms to maintain in-house R&D capacity and license earlier stage technology. Second, as mentioned in the previous section, patents have empirically been quite powerful in the biotech and pharmaceutical industries. For these reasons, our experts suggested that the market for university technologies in the biotech industry has become competitive and that basic biological research discoveries are currently driving both academic research and commercialization.

There are several additional, well-understood reasons for the close ties and relatively efficient market in university biotech licensing. First, as one industry executive observed, many biotech companies have one decision-maker with the authority to invest in new technologies. This emphasis makes clear sense when placed in context of the importance of acquiring university technologies early in their development. Second, as suggested by our interviewees, venture capitalists seem fairly patient with the long time horizon typically associated with developing biotechnology. Increasingly, however, venture capitalists demand broader "platform" technologies before agreeing to invest in a start-up. More and more, young biotech companies are becoming alternative licensors of technologies that used to be the basis for start-ups. Third, where there is a critical mass of biotech activity in a geographical area, there is typically greater industry access and interaction. Biotech licensing is exceptional, for example, in the Boston area because of the strong research generated at Harvard, MIT, and the area teaching hospitals. Finally, the biotech industry *originated* from universities, and many of the founders of biotech firms come from academia. Their cultures are similar, and comprise high levels of mutual familiarity.

IV. RECOMMENDATIONS

Based on findings from our case studies and interviews, we offer two sets of recommendations. The first set is tailored to university TLOs. While these visions may be controversial, we believe that TLOs can benefit by considering strategic future directions for their organizations. TLOs operate with limited budgets and resources. We fully recognize these constraints and have designed our recommendations with them in mind. We focus on latent resources in order to broaden licensing officers' reach. Most TLOs do some of these, but few or none do all. The second set of recommendations is targeted to the Association of University Technology Managers (AUTM).

A. Recommendations to University TLOs

The first half of the recommendations sets forth three conceptual categories, which are general strategies for TLOs. The second half presents a *menu* of potential paths for universities to consider, depending on their individual circumstances. For each recommendation, we also discuss potential obstacles.

Category #1: Harnessing Resources

• Increase "captive" audience networking. Draw more frequently on the expertise and advice of existing licensees and previous investors. The licensees we interviewed in this category believe they are underutilized, and expressed unanimous willingness to help licensing officers with strategies and leads. The captive audience also expressed strong interest in networking opportunities with other existing licensees.

• Aggressively draw on inventors' resources, contacts, and strategic guidance. TLOs recognize inventors as perhaps the most important source of contacts and licensee ideas. However, almost all the inventors we interviewed felt they

could be more strongly utilized. We recognize that few inventors will be willing to do all of these (and some may not be able to offer much help). Yet many inventors will do more of these things at least some of the time, with great potential benefit.

> Ask inventors to establish industry contacts at seminars and conferences, contact colleagues for advice and leads, and think seriously (albeit briefly) about possible licensing strategies. Contacting former students and researchers (who might now be at established firms or interested in starting up a company) from the inventor's lab may also be useful.

• Draw (*informally*) on professors and other experts within the university, especially those with previous experience in licensing technology, for marketing strategies and leads. Aggressively follow up on the contacts and leads from these experts.

• Hire interns. Students from local business and management schools, for example, can conduct detailed, targeted market research. Law school students can help in patent searches. This strategy might take some of the workload off licensing officers.

> A potential obstacle to this strategy is the ramp-up time necessary for interns to become familiar with the licensing process. One option would be to work with professors to structure longer internships, potentially making this recommendation viable. A second would be to target students who already have relevant knowledge in fields closely allied with a TLO's needs.

• Target business school graduating students. Many of these students are interested both in commercializing technology and in entrepreneurship and may be interested in licensing technologies. Our cases also strongly suggest that often only a motivated entrepreneur will do the leg-work and networking required to attract investors. In fact, the VCs we interviewed stated that commitment of an entrepreneur is a very important determinant of success.

Category #2: Non-captive Audience Networking

Almost all of our existing company interviewees explicitly expressed willingness to respond to personal, targeted outreach efforts. They were up front about tactics that do not work (such as untargeted mass mailings), and about the stigma such efforts can create, both for technologies that are marketed in these ways, and for a TLO's reputation. Our interviewees also offered advice regarding potentially fruitful tactics, including:

- Careful research: use university resources to identify companies and the right people within those companies for the specific technology in question.

> Face-to-face contact with follow-up is essential. Licensing officers should visit industry heads of technology acquisition and heads of research and development, or invite them to the university campus (in collaboration with the inventor, if possible).

- Conduct site visits to firms once or twice a year, focusing on licensee targets with broad potential, or perhaps on the most promising non-moving technologies.

> We recognize that in addition to budget and time constraints, TLOs would face a multitude of choices in implementing this recommendation. Our suggestion is that they start by choosing one or two companies which make strategic sense.

- Do not push imperfectly matched or insufficiently-proven technologies on valuable potential licensees.

Category #3: Strategic Focusing of Effort

- Undertake second round marketing efforts for promising unlicensed technologies. This is especially applicable for technologies in industries just recovering from economic downturns, or for technologies after a major technical advance. Furthermore, several of our cases suggest that researchers sometimes achieve important advances subsequent to an initial round of licensing effort; and these technologies might very beneficially be showcased a second time. Possible strategies include assigning an intern to such cases, or setting up systems to monitor unlicensed technologies for such developments.

Category #4: Performance Measurements

- TLOs should adopt measures to better evaluate their performance in delivering social value. TLOs could measure *annually*: (1) technologies licensed as a share of total committed technologies; and (2) total committed technologies as a share of total disclosures received.

> As mentioned previously in this paper, these two measures are also imperfect; while low ratios and high ratios for both (1) and (2) unambiguously suggest poor and excellent performance, respectively, it is unclear how to evaluate the performance of a TLO that has a high ratio in one measure, but a low ratio in the other.

The following is a menu of longer-term, overarching options available to university TLOs. Though potentially controversial, we believe that TLOs moving toward a broader conception of technology transfer would generate greater benefits for society.

Alternative #1. Adopt a more aggressive licensing strategy. One of the first tasks in implementing this alternative is to gain top level university support for greater risk taking and an aggressive stance toward technology licensing. Other steps might include:

- Promote a willingness to commit to commercializable technologies, including bearing the risks and up-front costs, even if a prospective licensee has not yet been identified.

- Concentrate more on managing and using resources. Engage networks and let them do some of the work. TLOs enjoy a wide array of potential resources, including prior licensees, professors (as advisors), students (as interns), and, perhaps even alumni.

  One specific idea for drawing on alumni is to seek out alumni in target companies and secure information on best marketing approaches and appropriate contacts.

- Plow back some royalty revenues into the licensing process. Reinvesting would allow TLOs to move further right on the commitment spectrum.

- Build a search *strategy*. This includes: focusing on the highest value-added technologies; categorizing technologies by size, stage, and potential licensing paths; adopting more flexible financing arrangements for licensing, royalty, and milestone payments for small business or start-up licensees.

Alternative #2. "Ripen" technologies too embryonic for private markets. TLOs might actively seek mechanisms, including sponsored research and private ripeners such as Battelle Memorial Institute and similar institutions, to perform the applied research necessary to bridge the gap for high potential, embryonic technologies.

Alternative #3. TLOs might begin to consider more functional alliances across universities. Licensing officers in even the larger TLO offices spend significant amounts of time learning new sectors and new technologies. Creating mechanisms to capture the advantages of scale offered by cross-university cooperation might produce significant benefit for universities in general.

In addition to a very tricky question regarding implementation, there are at least two potential costs to increasing scale. First, increasing scale risks losing individual contact with the inventors, a critical asset. Second, conflict of interest issues could become quite complicated.

Alternative #4. Recognize the reality of limited resources and concentrate only on a limited number of cases. By trimming their portfolios, licensing officers would be freed to spend more time, effort, and care with each technology to which they commit. This includes greater marketing efforts, stronger collaboration with the inventor in building a licensing strategy, more thorough patent searches, and more research about and approaches to the right people in the right companies.

We believe that universities, each with a unique history, culture, and set of resources and constraints, should initiate the process of building community-wide support for the option(s) most consistent with their core missions.

B. Specific Recommendations for the Association of University Technology Managers (AUTM):

1. Offer a listing of university-sponsored start-up firms by industry and specific product. Start-up firms have unanimously reported interest in further licensing opportunities. Broadening the pools of both university generators of technology and potential licensees increases the likelihood of producing significant benefits.

   Details would have to be carefully thought out, but would probably include, at least, coordination through the responsible licensing officers.

2. Systematically tap into networks of private sector research directors. AUTM could forge formal mechanisms to enhance the ability of licensing officers to easily identify and contact appropriate targets and to increase the likelihood that those targets would respond.

   One idea could be to establish a relationship with hard to reach but promising industries, perhaps through their trade associations, or through research collaboratives such as Sematech or the Microelectronics and Computer Technology Corporation.

3. Create a mechanism to allow licensing officers to locate, quickly and unobtrusively, licensing officers with recent experience in a specific industrial sub-sector.

   A possible mechanism to share expertise might be Internet-driven pages containing files (and searchable keywords) for recent licensing deals or industry intelligence by industry sub-sector. Recent innovative or successful deal structures or relations with resources might also be included.

* * * * *

TLOs have come far since 1980 in learning how to license university-generated technologies. We believe that TLOs also have great potential to further enhance the public benefit. The challenge of licensing will become even more difficult, however, as the number of university technology disclosures quickly increases. We hope our insights and recommendations help TLOs as they assess their licensing strategy in this dynamic environment.

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