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**Reconsidering the Bayh-Dole Act and the Current University  
Technology Licensing Regime\***

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## ABSTRACT

The Bayh-Dole Act of 1980 has been hailed by policy-makers and scholars as a critical policy innovation for ensuring the commercialization of inventions resulting from results of federally-funded research. This paper suggests that the current implementation of Bayh-Dole through university ownership of all researchers' inventions is not an optimal system in terms of economic efficiency and social interests regarding the rapid commercialization of technology. The current regime, within which the university owns researcher inventions, is plagued by ineffective incentives, information asymmetries, and contradictory goals for the university, the inventors, potential licensees, and university technology licensing offices (TLOs). These structural uncertainties lead to licensing delays, misaligned incentives among parties, and delays in the flow of scientific information and the materials necessary for scientific progress. For the very best TLOs these difficulties can be overcome, but for the average TLO this misalignment of incentives creates suboptimal outcomes in terms of technology transfer. The institutional arrangements within which TLOs are embedded are so perverse that it has encouraged a number of them to become income maximizers and operate in a manner similar to what pejoratively have been termed patent "trolls."

To remedy this complicated skein of perverse incentives, we suggest two alternatives: The first alternative is to vest ownership with the inventor, who could choose the commercialization path for the invention. The inventor could then choose to contract with the university TLO or any other entity. The second alternative discussed is to make all inventions immediately publicly available through an open source strategy. Either of these alternatives would be more likely to achieve the social goal of early technology adoption.

## Preamble to the Bayh-Dole Act of 1980

It is the policy and objective of the Congress to use the patent system to promote the utilization of inventions arising from federally supported research or development; to encourage maximum participation of small business firms in federally supported research and development efforts; to promote collaboration between commercial concerns and nonprofit organizations, including universities; to ensure that inventions made by nonprofit organizations and small business firms are used in a manner to promote free competition and enterprise without unduly encumbering future research and discovery; to promote the commercialization and public availability of inventions made in the United States by United States industry and labor; to ensure that the Government obtains sufficient rights in federally supported inventions to meet the needs of the Government and protect the public against nonuse or unreasonable use of inventions; and to minimize the costs of administering policies in this area.

Congress's goal in passing the Bayh-Dole Act (B-D) in 1980 is clearly outlined above. B-D was passed because of a belief that the commercialization of federally-funded research results was retarded by the federal ownership of the intellectual property rights to the research results. Further, on the basis of little evidence, it was believed that foreign firms were appropriating the benefits of these inventions.<sup>1</sup> B-D standardized the procedures and ratified the transfer of control of federally-funded inventions to the contractors, including universities (Mowery et al. 2004; Slaughter and Rhodes 2004).<sup>2</sup> Many have hailed the new regime within which the university owns the inventions, in both a popular press and academe, as a boon to the goals of B-D. As in the case of the dominance of the QWERTY keyboard, so eloquently analyzed by Paul David (1985), today's university patent ownership regime is treated like Candide's "best of all possible

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<sup>1</sup> The use of foreign competition to justify particular U.S. policies is not novel.

<sup>2</sup> Many major research universities already had Institutional Patent Agreements with various Federal funding agents, though these varied by agency.

worlds.”<sup>3</sup> This paper is framed as an invitation to reopen the debate about the best method for encouraging technology transfer.

In a recent paper, Litan et al. (2007) argued that the current operation of B-D has not been socially optimal. This paper builds upon their insight and expands it, showing that the current university ownership of intellectual property is not optimal in terms of efficiency or effectiveness in encouraging technology transfer. These were the goals set out for B-D. Further, we show that there are potentially superior solutions to extracting societal benefit from the fruits of federally-funded university research.

The current regime, within which the university owns researcher inventions, is plagued by ineffective incentives, information asymmetries, and contradictory goals for the university, the inventors, potential licensees, and university technology licensing offices (TLOs).<sup>4</sup> These structural uncertainties lead to licensing delays, misaligned incentives among parties, and delays in the flow of scientific information and the materials necessary for scientific progress. Most important, this state of affairs exists even while superior solutions for transfer exist. The current invention technology transfer regime is inherently economically inefficient and ineffective because it contains perverse incentives and irreconcilable contradictory goals that handicap all parties.

Efficiency and effectiveness in encouraging technology transfer do ignore normative issues that might outweigh efficiency arguments. For example, if the university pays the salary of federally-funded researchers and provides the environment within which they invent, is the university entitled to a share of the value that invention

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<sup>3</sup> For a fascinating analysis of the justifications of this new regime in social construction of science terms, see Glenna et al. (2007).

<sup>4</sup> We do not use the term “technology transfer office,” because the goal and charge of nearly all of these offices is invention licensing. For a comprehensive review of the literature on TLOs, see Phan and Siegel

creates? If answered in the affirmative, this question leads to another, “by what mechanism?” Similarly, one might ask whether and how society should be compensated. These normative questions are vital; however, in this paper they are bracketed in the interest of exploring and critiquing the current arrangements.

After critiquing the current arrangement, we explore two different models for handling inventions made at universities. The first solution we explore, and one of the possibilities advocated by Robert Litan et al. (2007) is to vest all intellectual property (IP) rights with the inventor because they are best placed to exploit the invention. This solution does not preclude a role for the university TLO, but the model would transform the TLO into a service organization acting as the inventor’s agent, rather than the invention’s proprietor. Along the lines of Richard Nelson’s (2003) article, but going even further, there is another, radically different, solution, which is to make all inventions Open Source automatically placing them into the public domain (Rhoten and Powell 2007). In this case, society is expressing its trust that the capitalist market can develop business models capable of extracting value from new inventions. Either solution has drawbacks, but both offer important advantages over the current university patent ownership regime.

The paper begins with a brief overview and history of B-D and its implementation in the university. The next section questions whether the university’s goal in claiming ownership in its employees’ inventions represents a technology transfer or a desire to profit from these inventions. Using examples, this section illustrates that patenting is not necessary for encouraging technology transfer in many cases. These illustrations are

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(2006). For an excellent review of the literature on university-based entrepreneurship, see Rothaermel et al. (2007).

followed by an analysis of the TLO-inventor relationship analytically presenting the contradictory goals, information asymmetries, and perverse incentives that result from the current university patent ownership regime. The penultimate section examines two alternative schemes for apportioning ownership of university invention. Namely, the university must grant all ownership rights to the inventor; or the university must renounce all ownership rights and place inventions in the public domain. These two outcomes of our analysis are followed by a concluding discussion suggesting that academic research should deploy models that are more realistic of the ways in which technology is transferred to the general economy and reconsider the current university patent ownership scheme.

## **Background**

B-D limited federal government rights (to the retention of a royalty-free, non-exclusive license) to the inventions created by federal contractors, including universities. The belief was that with university ownership of the inventions, they or their licensees would have greater incentives to invest in commercialization, thereby fueling the growth of U.S. competitiveness. In some cases, universities, as a condition of employment, already claimed their employee's inventions, but B-D transferred the rights to the inventions to federal contractors. Universities could now receive clear title to their employees' inventions, but with this right came an affirmative obligation to market them actively (Eisenberg 1996; Mowery et al. 2004; Sampat 2006).

B-D was not an immaculate conception, but rather the outcome of lobbying efforts by corporations and university licensing officials intent on securing access to

inventions (Eisenberg 1996: 1726; Sandelin 2007). For the universities, the desire to appropriate the fruits of their employees' federally-funded research was undoubtedly fueled by the emergence in the late 1970s of a venture capital-financed biotechnology industry. The excitement culminated with the spectacular 1980 Genentech initial public offering (Kenney 1986). This promise of riches was in part because patents for proprietary human therapeutics are easily defended, and they are therefore particularly well suited to monetization by organizations such as universities.<sup>5</sup>

As an organization, despite the frequent debates on the desirability of university commercialization (Etzkowitz 2002; Kenney 1986; Slaughter and Leslie 1997; Bok 2003), the research university is not a business entity; generating income from inventions cannot be its primary motivation. In U.S. universities the two primary motives are the education of future citizens and workers, and conducting research for the advancement of knowledge. Neither of these motives is easily measured by profit, and there is the constant necessity to balance these usually congruent, but sometimes contradictory goals.

The congressional motivation in passing B-D emanated from the perception that a large number of patents resulting from federally-funded research were unexploited due to insecurity regarding their ownership (Eisenberg 1996; Mowery et al. 2004). This perception was heightened by fears that the U.S. economy was falling behind Japan. University administrators and corporate executives exploited this concern with declining competitiveness by telling legislators that the university could be the source of innovations that would reinforce U.S. economic preeminence. Universities across the country avowed readiness to enlist in this mobilization (Brooks 2003). The implicit

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<sup>5</sup> Donald Kennedy (1981), then president of Stanford University captured this when he observed that, "these firms are being capitalized so that much of the incremental value is being realized before a product

theoretical model held that universities would be sufficiently self-interested to respond to the offer of invention ownership made while conducting federally-funded research (Rafferty 2008). Congress was correct in that university administrators took B-D as a signal that staff inventions could be the source of revenues.

With only a few exceptions, inventions made at the university are university property. At Stanford University until 1994, when the policy was changed to require faculty to transfer their invention rights to the university, inventors owned the patent rights.<sup>6</sup> Another exception is the University of Wisconsin, Madison, which had traditionally allowed inventors to retain rights to inventions, though it required that inventions made with federal funds be assigned to a legally separate non-profit entity, the Wisconsin Alumni Research Foundation (WARF). The WARF model is an exception because legally it is not a part of the university. The norm has been that a university office, charged with managing licenses, undertakes ownership and licensing.

Prior to B-D, the federal government owned inventions made with federal funds (unless an Institutional Patent Agreement was in place). It is plausible that these inventions were not being commercialized rapidly because of a lack of ownership clarity. Of course, at the time, the faculty at most universities also exhibited less interest in commercializing inventions. This ethos was likely already eroding during the 1970s as biology, the largest recipient of federal funding, underwent a technological revolution, making research results more commercializable and, in certain cases, quite lucrative (for an extended treatment of this phenomenon, see Kenney 1986). Already in engineering

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is on the market or before it is even very sure that there will be one.”

<sup>6</sup> This change did not appear to affect Stanford’s success at transfer. This is likely because the university was located in a munificent environment, the TLO had a legacy of being a “service” organization, and had previous technology transfer success (on the importance of previous success, see O’Shea et al. 2005).



and chemistry there was a long history of commercialization of university inventions, although largely through individual faculty efforts and the Research Corporation (for a discussion of this see, Mowery et al. 2004 Chapters Two and Three). B-D was a formalization of an extant movement at a number of elite schools, but it undoubtedly also alerted faculty and administrators still operating under a previous social ethos that universities should not seek to patent or to commercialize their research. Conditions were changing. With visions of a new income source, university administrators responded by establishing a new organization, euphemistically termed the “technology transfer office” or, more correctly termed, the “technology licensing office.”

Implicit in the models many economists and policy-makers have of the technology transfer process is the assumption that university inventors are employees in the same way as corporate researchers are employees. Yet the labor market within which a university inventor, particularly a professor, is embedded differs from that of a corporate researcher. For example, it is nearly impossible to terminate the employment of a tenured faculty. The preponderance of university research support is extramural, for specified projects, and subject to little control by university administrators. Certain valuable faculty outputs, such as text books, belong to the faculty and not the university. A faculty member’s work process is largely immune to direct control and supervision by the administration. In contrast, the source of the corporate researchers’ funds is, as a general rule, internal; and managers have direct control over the funds; and employment can be terminated at will.

It is difficult for the administration to control faculty research. In part, this difficulty is in part because each faculty member has a unique specialization whose

substantive content may not be understood by putative supervisors, and the first-line supervisor, the department chairperson, is a colleague. For performance evaluation, administrators rely upon departmental colleagues and the external invisible college of peers to pass upon research quality, funding requests, and personnel decisions, which are decided on the basis of performance in teaching and research. These arrangements suggest that models based upon understandings of conventional non-profit hierarchies or corporate employment relationships are unsuited for understanding the university's relationship to its employees. Modeling professors with the same constraints, motivations, and structural position as employees of a for-profit firm or, for that matter, a bureaucracy is fundamentally flawed.<sup>7</sup>

Because of the employment relationship in the university, hierarchical power is difficult to assert directly, and researcher motivations are multifaceted and difficult to manage and model. The university inventor has significant independence, subject to little effective oversight – a recipe for a complicated relationship and a lack of corporate-style accountability.

### **Is Technology Transfer the Goal?**

Universities have become increasingly important generators of knowledge that has value in the commercial sphere. One powerful constraint on universities is that, even

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<sup>7</sup> Suggestions by Link et al. (2007) that patents, invention licenses, and establishing new firms be used to evaluate faculty performance are radical and not based on any conventional understanding of the most important roles of the university in society. This radical suggestion is probably generated by an adoption of the perspective of the TLO employees Link et al. interview, most of who are assessed by the income they generate, and usually have little idea of what constitutes the building blocks of university excellence. Top-tier research universities have always been careful to exclude such considerations because this would be very likely to encourage short time-horizon research and low quality “job shop” style of research. To suggest that academic excellence be equated with commercialization indicates a deep misunderstanding of how “elite” universities built their reputations.

though they have non-profit status and can legally sell intellectual property, they are not permitted to enter the marketplace selling finished products. The result is that they must sell their inventions. Universities recognize this obstacle. So, for example, in 2006 Harvard University created a development fund to allow Harvard scientists to pursue technology development work at the university rather than licensing their inventions at an early stage. The objective was to move further down the commercialization path and make the inventions more valuable to companies, i.e., capture more of the value of the invention (Ciarelli and Schuker 2007; Ready 2006). Here, Harvard is entering into what normally is the province of the venture capital-financed startup. In addition, this shift increasingly challenges the line of demarcation between the profit-oriented world of business and the non-profit world of the university.

The TLO is the university organization designated to operate at the interface with commerce. As such, it is situated in an inherently contradictory location. If the objective of the TLO is to generate licensing funds for the university, then the TLO should be judged on its profitability. The greater good of society, a difficult phenomenon to measure, would not be a relevant criterion.<sup>8</sup> The ultimate question is whether an intermediary is necessary to transfer technology from the university to the private sector. Or would the technology be transferable without the intermediary? To answer this question, it is important to consider the likelihood of transfer for differing categories of inventions and the conditions for such transfer.

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<sup>8</sup> Apparently, in August 2007 the U.S. Internal Revenue Service was investigating UCSD regarding its profit making activities including those related to income from patents and licenses (Su 2007). Of course, if the universities are intent on profits, then their tax-exempt status might also be questioned, but that is another topic not for this essay.

The patent literature suggests that in electronics, software, and engineering in general, patents have greater value in defending against patent litigation, though this may be changing due to ever more expansive grants of patent protection (Levin, Klevorick et al. 1987; for semiconductors, see Hall and Ziedonis 2001; Ziedonis 2003; for nanotechnology, see Lemley 2005). The significance of university patents in software and electronics in terms of facilitating technology transfer is dubious (Jaffe and Lerner 2004). If one considers university-affiliated information technology (IT) startups during the last three decades, some did not have university licenses: Cisco (Stanford), SUN Microsystems (Stanford), and Yahoo! (Stanford), while more recent ones, such as Akamai (MIT), Google (Stanford), Lycos (CMU), and Netscape (University of Illinois), did have licenses. However, it is not clear that patent protection was required to ensure their commercial success. If TLOs and patenting are less likely to be significant in assisting the transfer and commercialization process in the IT and engineering fields, then possibly TLOs and patents are more valuable in fields such as the biological sciences – an observation that academic research supports (Cohen and Walsh 2002; Coriat et al. 2003; Lim 2004; Merges and Nelson 1990).

One of the most valuable university patents ever issued, the Cohen-Boyer (C-B) patent, was a process patent issued in 1980 on a technique for the creation of genetically engineering microorganisms (Hughes 2001; Kenney 1986: 258; Powell et al. 2007). Over its 17-year life, it collected over \$255 million revenues for the Stanford University and the University of California. The vast majority of these revenues represented royalties on human therapeutics developed using the technique. The history of the Cohen-Boyer patent is revealing. Maryann Feldman et al. (2007) concluded that one lesson from

Stanford University patenting of the C-B technique was that “had it not been for Stanford’s enlightened licensing practices, the Cohen-Boyer technology might have been placed in the public domain where the technology could have remained undeveloped or in the laboratories of large established pharmaceutical companies.”<sup>9</sup> Yet the fact that C-B was non-exclusively licensed calls this conclusion into question. Niels Riemers, the founder and first director of the Stanford Technology Licensing Office who was responsible for the patent filing, is quoted as saying that it was already being used at the time of its filing (Reimers as quoted in Sampat 2006). University laboratories around the nation began using C-B immediately after it was first revealed at a 1973 Gordon Conference. By 1978 there was frenzy among venture capitalists to fund genetic engineering startups, and large pharmaceutical firms were investing in internal genetic engineering capability, which clearly means they were already using the C-B technique. The communities of practice within which elite scientists are embedded ensure that any powerful new tool is adopted almost immediately.<sup>10</sup> Even if C-B had never been patented, the fact that Genentech—established by Herbert Boyer and a venture capitalist Robert Swanson in 1976—used this technique for all of its major drugs is evidence that the technique would have been used regardless of whether it had been patented or not.

There is a contemporaneous and nearly identical counterpart with which to judge the claim that the Cohen-Boyer (C-B) invention might have remained unused had it not been patented. In 1975, while working at Cambridge University, Georges Köhler and César Milstein in a short letter to *Nature* described how to produce what came to be known as monoclonal antibodies (MABs). MABs can be engineered to target specific

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<sup>9</sup> Of course, once the Cohen-Boyer technology was published it could no longer have been patented by anyone except the inventors, so the possibility that a large pharmaceutical firm could have patented the drug is not possible.

cell receptors, and thus they offer a powerful new enabling general-purpose technology.<sup>11</sup> Had the invention been patented, it would have been a basic patent (Oliver and Liebeskind 2003). And yet, though the inventors explicitly stated in their letter to *Nature* that “Such cultures could be valuable for medical and industrial use” (quoted in Cambrosio and Keating 1995: 8). And yet, the inventors decided not to patent the discovery and placed it into the public sphere.

Following the reasoning of Feldman et al. (2007), one might expect that MABs would languish unused. Yet in 1978, exactly three years after the short letter in *Nature*, the first MABs-based firm, Hybritech, was established in San Diego despite the fact that the inventors were not in close proximity to the star scientists (Kenney 1986). Soon a wave of MAB firms was established and large pharmaceutical firms quickly integrated MAB technology into their tool kit. This suggests, at least in regard to general purpose technologies such as C-B or MABs, that there is little reason to believe that inventions would be unused due to a lack of proprietary protection or even that their diffusion would be retarded.<sup>12</sup> Since there was a non-exclusive license with an up-front fee and royalty clause for C-B, it is a simple economic exercise to demonstrate that a patent would not encourage usage, but rather that experimentation for commercial purposes would be discouraged – the license is simply a cost (Mazzoleni 2006). Both C-B and MABs contributed to an efflorescence of entrepreneurship, but patenting was irrelevant to adoption.

The previous examples originate from the inception of an industry. The invention of human stem cell lines is a contemporary example. Human stem cell lines that are the

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<sup>10</sup> For discussion of communities of practice, see Lave and Wenger (1991).

<sup>11</sup> Georges Kohler and Cesar Milstein were joined by Niels K. Jerne in winning a Nobel Prize for this work in 1984.

current object of controversy were developed at the University of Wisconsin, and the patent rights were assigned to the Wisconsin Alumni Research Foundation (WARF), a private entity (Jain and George 2007). Aware that stem cells might have commercial possibilities, WARF designed a licensing agreement to be applied to every potential user, even university researchers. The licensing agreement stipulated that WARF could “reach” through and demand royalties for any invention using their stem cell lines. For example, WARF demanded royalties from any invention by the non-profit California Institute for Regenerative Medicine, which was established by California voters to accelerate stem cell-related research. WARF, though having non-profit status, was operating like a profit-making entity – not an institution supported by tax payers.

The University of Wisconsin, Madison, through its agent WARF, zealously targeted firms and research institutions (*Stem Cell Business News* 2007).<sup>13</sup> The startling aspect of Wisconsin’s efforts is highlighted by a recent news report in which another scientist stated that “The real discovery of embryonic stem cells was by Martin Evans, Matt Kaufman, and Gail Martin in 1981, and none of these scientists considered patenting them.” The scientist concluded, “It is outrageous that WARF claimed credit for this landmark discovery nearly 15 years after it was made (*Stem Cell Business News* 2007).” Under intense pressure, WARF withdrew its demand that the California institute pay royalties (WARF 2007), but the incident demonstrates that income rather than technology transfer was the goal. With WARF operating like a private sector entity, might it not better be treated as such? WARF and other TLOs, such as Columbia, have extended their property rights claims far beyond the intent of the framers of B-D.

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<sup>12</sup> On general purpose technologies, see Bresnahan and Trajtenberg (1996).

These concerns are echoed in the increasing number of university patents on biological materials, nearly all of which are based on taxpayer-funded research (Mowery and Ziedonis 2007; Walsh et al. 2007). For example, Walsh et al. (2007: 1193) found that “even for transfers from one academic institution to another, where NIH guidelines [that suggest that reach-through rights and royalties not be required] are likely to apply, 29 percent of [material transfer agreements] included a reach-through right and 12 percent included a request for a royalty.” This approach suggests that university TLOs are treating the research enterprise itself as an opportunity to generate revenues.

This section used illustrations to question the proposition that university TLOs are necessary for the commercialization of university inventions. The evidence suggests that the only transfer the preponderance of TLOs are interested in is one from which they can extract rents, and that many are willing to impede technology transfer to collect those rents. As Mazzoleni (2006) demonstrates in cases where non-exclusive patents are granted, the patent merely redistributes the revenues generated by its use. He did not consider the question of whether the university or the inventor would be the better owner of the invention rights. The next section explores the relationship between the inventor and the TLO and suggests that the current ownership-based TLO model is an economically ineffective and inefficient organizational solution for maximizing the social benefit of university-generated inventions.

## **The Inventor-TLO Relationship**

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<sup>13</sup> A possible remedy here would be for the Internal Revenue Service to decide that WARF is competing with for-profit patent licensing corporations and withdraw its non-profit status.



In the United States, inventions made at the university de jure belong to the university. Their disposition is nearly always through a TLO of some sort (though, in a few cases, such as the University of Wisconsin, Madison, a private third party may be delegated ownership). Consider the situation when a professor discloses an invention that the TLO believes has commercial value. In even the simplest transaction there are two actors: the inventor and the university TLO, and an implicit third actor, if the invention is licensed, the licensee (this triangular relationship is depicted in Figure One). The inventor may also become the licensee. In the following sections we examine the role of the TLO and the inventor, but not explicitly the licensee. By examining this simplified representation much can be understood about the contradictions and dilemmas in the university technology licensing process.

### *The TLO*

Even the largest TLO represents only a small part of a major research university and a small portion of its total revenues. TLOs have different organizational locations within the university, but most often they are situated under the administrator responsible for research. Over the last two decades, TLOs have grown in number, size, and cost. In 2007, approximately 20 percent of the TLOs had more than fifteen TLO professionals (AUTM 2007), and for such large TLOs direct and indirect expenditures are likely to be approximately \$2 million.<sup>14</sup> The financial returns from TLOs vary significantly, but the most successful have gross returns of between \$20 million and \$60 million, while most have returns under \$5 million. One outlier is NYU, which received \$197 million in 2006,

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<sup>14</sup> This is an estimate based on the assumption that professionals would have cost approximately \$150,000 each if all benefits and overhead costs were included.

and likely Columbia University, which did not report its income to AUTM (AUTM 2007).

For administrators, TLO income is attractive because the funds are unencumbered. Often the support monies for TLO personnel can originate from public funds, either federal or state. And yet, TLO earnings are unrestricted since administrators can spend them for whatever they feel is necessary. This is a powerful incentive—restricted funds are spent to operate the TLO, while earnings are regarded as unrestricted funds. The strength of this incentive is difficult to measure, but it is likely to be considerable as unrestricted funds are invariably in short supply.

The academic writings on TLOs have often been theoretically confused, and any analysis of the TLO's role must first clarify these confusions. For example, some scholars model the TLO in a principal-agent framework (e.g., on principal-agent, see Jensen and Meckling 1976). For example, Markman (2004) considers the TLO as the inventor's agent, an impossible formulation because the inventor has no contractual authority over the TLO. A somewhat different formulation by Jensen and Thursby (2001) models the TLO as an agent of both the inventor and the university. Though not precisely correct, the relationship does indicate the contradictory situation that the TLO faces because it functions only as an agent of the university, although it depends upon the inventor's knowledge and goodwill in a situation. In fact, the professor is an agent of the university! But in this particular relationship, the TLO has only a tenuous and highly mediated control of the inventor who is the university's agent. For these reasons, characterizing the inventor-TLO relationship as one in which the TLO is an agent of the

inventor is simply not useful. In this section we begin a line of theorizing that provides more nuanced appreciations of the TLO-inventor relationship.<sup>15</sup>

A world of zero transactions costs, which would mean perfect information for all parties regarding the value of an invention, no time constraints, infinite bargaining time on the part of the inventor, costless transactions between the university, inventor and licensing firm, or just between the university and inventor/entrepreneur in the case of a startup, would result in a socially optimal outcome. Perfect information allows all parties to see the same benefit from an invention, and bargaining among the parties would result in costless sharing of this benefit regardless of whether the university or the inventor owned the invention. In such a world the assignment of property rights would only impact the distribution of wealth among the parties, not the allocation of resources (Coase 1960). But, as Coase (1988: 174-179) made clear, this assumption of zero transactions costs operates only as a device to illustrate the essential aspect of transaction costs in the real world. We take a similar view here.

Calabresi and Melamed (1972) analyzed entitlement protection through property rules and liability rules in a world characterized by transactions costs and imperfect information. The basic rule for economic efficiency is that entitlements should be assigned to the party most likely to make optimal market judgments. That is, property rights should be assigned so that the resulting market allocation comes closest to the optimum given the particular set of transaction costs that parties face. These same insights can be applied to intellectual property rights in the case of university inventions. That is, a parallel can be drawn between the concept of least cost avoider in the case of

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<sup>15</sup> On the value of appreciative theorizing, see Nelson (1995).

externalities, and the least cost (or most effective) innovator in the case of technology transfer.

The literature on university technology transfer and licensing of inventions recognizes some of these points. For example, with regard to B-D, based on their survey work, Jensen and Thursby (2001) start with the observation that most university inventions, when they are licensed, are at such an early stage of development that additional inventor involvement is very often needed to attain commercial success.

In their theoretical work, Jensen and Thursby model a university invention such that it is owned by the university and licensed by the university TLO to an outside firm. Because inventor involvement is required to increase the probability of successful commercialization, the TLO must write a license contract that induces effort from the inventor over the period of development from the time the invention is disclosed to the time the licensee firm decides whether to put the invention into production. The typical contract consists of an upfront license fee the firm pays to the university, which shares it with the inventor and a revenue-based payment by the firm to the university, which is also shared with the inventor. This sharing is meant to induce the inventors to disclose inventions and assist in their commercialization. Although Jensen and Thursby did not attempt to characterize optimal contracts, they did show that an equity contract is more efficient than a contract based on royalties.

Robert Lowe (2006) builds on Jensen and Thursby's theoretical work to expand the analysis of university technology transfer to include both the licensing of university inventions and the creation of startups to commercialize university inventions. Unlike Jensen and Thursby, Lowe presents a base model in which the university inventor owns

the property rights to the invention, and then introduces the university TLO as the intermediary required by B-D. The two cases allow a comparison of the welfare and economic efficiency differences between these two property right assignments.

The base case of Lowe's model is quite similar to Jenson and Thursby's except that the inventor has the option of forming a startup instead of licensing the invention. Another variation suggests that inventions differ in the extent to which tacit knowledge, held only by the inventor, is required to commercialize the invention. When Lowe introduces the university, as the intermediary between the inventor and the potential licensees, the outcomes change. Now the TLO expends a fixed cost to market and manage the invention, and in return it negotiates the license contract with an outside firm, or in the case the inventor founds a startup and negotiates a contract with the inventor. When the inventor forms a startup, the inventor pays a fixed fee upfront to the university for use of the invention and royalties—should the invention be successfully commercialized (of course, the university could also demand equity). This role of the university produces two differences from the base case in which the inventor owns the invention. First, if the royalties are based on revenues, the profit and output of the firm is reduced, resulting in a Pareto inferior outcome. Second, because of the reduced output and license costs the inventor is worse off and the university is better off.

A justification for university ownership is that it administers and manages the intellectual property of the university inventor. This justification, though, most reasonably applies in those cases in which the invention is licensed. If the inventor is intent upon establishing his or her own firm, there is no economic reason for university TLO involvement. In cases in which the university negotiates with an outside firm, it

might be argued that the TLO has an advantage in marketing inventions and finding licensees for these inventions. In such a case the TLO can improve upon the base case contract if it can find licensees that the inventor could not find. This improvement can be Pareto superior in that both the inventor and the university are made better off by the TLO's knowledge of the market. If the TLO does not have superior knowledge, then the university simply taxes the invention, presumably resulting in less effort by the inventor in developing the invention, a Pareto inferior outcome.

Thomas Hellman advances an affirmative case for the TLO in commercialization (2007). In Hellman's model the assumption is that the TLO, acting on behalf of the university owning the patent, has superior knowledge on how the invention may be used and by which firms. The general result is that the inventor is better off by delegating the search for licensees to the TLO, and that such a result is optimal. Of course, if the TLO is not more effective in this search than the inventor, then it is preferable to transfer intellectual property rights back to the inventor (Hellman 2007: 28). Hellman assumes there are no transaction costs and that time has no value in the claiming or returning of patent rights.

Does the TLO, as Hellman (2007) argues, have search capabilities superior to the inventor? It is almost always the case that the inventor is steeped in the literature of the invention, knows current research competitors whether they are working in public or private sector institutions, and has tacit knowledge about the invention and its possible applications. This case Thursby and Thursby (2003) confirm through their observation of “the extreme importance of personal contacts between the firm’s R&D staff and university personnel.” Not only are the inventors likely to have the best knowledge of

which firms might be interested in an invention, but also they play a vital role “in the transfer of technology after an invention is made.”

To illustrate the improbability of TLOs understanding all technologies and markets with which they must deal, consider the Ohio State University Technology Licensing and Commercialization office. In 2006 Ohio State had the eleventh largest university research budget expending \$652,329,000 (NSF 2007). The licensing operation employed 16 professionals (Ohio State University 2007) and earned \$957,000 in fiscal year 2007 (Gibson 2007). There is no reason to consider the operation atypical.

The OSU Technology Licensing and Commercialization Website lists inventions currently available for licensing.<sup>16</sup> The Website is divided into 19 separate technology categories with 308 total listings, and within each there are multiple inventions (some inventions are listed in multiple categories). These were only the inventions that the TLO believed were sufficiently promising to patent and pursue. In Table One, a sample of available OSU inventions is presented. Each category contains an eclectic set of inventions. Three inventions from the agricultural and food processing category—a way to make “heart healthy soybean bread,” a technology to create new fruit shapes, and a molecular biology assay to detect a livestock disease—demonstrate the intra-category diversity. There is similar diversity in the other categories. The technology transfer personnel cannot be aware of the nuances of the technology and the relevant business opportunities—not because of a lack of competence, but because the inventions stem from radically different practice communities.

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<sup>16</sup> Whether the website lists all inventions is uncertain. However, since B-D requires a good faith effort on the part of the universities to license any patented inventions, it is likely that the list is fairly complete.

Given the importance of the search capacity of the TLO to the discussion of university technology transfer, there has been some empirical work. In a survey of 1,140 licenses, Jansen and Dillon (1999) found that TLOs reported that inventors contributed 54 percent of the leads for executed licenses. Licensing officer contacts and marketing efforts contributed only 19 percent of the successful leads. Ramakrishnan et al. (2005) analyzing the origins of 281 license agreements completed by the National Institutes of Health (NIH) between 2001 and 2004 found that inventors provided 38 percent of the leads for licenses, while marketing by the NIH Office of Technology Transfer provided 34 percent, and 28 percent of the leads were found through public information such as scientific publications and patent searches. Apparently, the results differ depending on the category of inventions. The sample is made up of two categories: commercial licenses (158) and biological material licenses (123). The inventor accounts for 33 percent of the leads for commercial licenses but 45 percent for biological material licenses, while NIH Office of Technology Transfer marketing accounts for 40 percent of the leads for commercial licenses but just 26 percent for biological material licenses. The authors explain these differences in source leads between these two categories by the location of the inventor in the scientific community. They conclude, “Generally, biological materials are licensed because of purely scientific considerations, while a commercial patent license takes longer, is involved and is usually a business decision” (Ramakrishnan et al., 2005: 350). Using a smaller qualitative sample taken from four elite universities, Colyvas et al. (2002: 65) found that for most university inventions the industrial and academic researchers knew each other and there was no wide divide requiring “technology transfer.” In the one case, in which such relationships did not



exist, they found that the TLO was unsuccessful in arranging a transfer (Colyvas et al. 2002:66).

In certain cases, compared to the inventor the TLO might hold an advantage in managing the invention. But as we would expect, the more tacit is the knowledge held by the scientist, and the more knowledgeable the scientist is as to how this invention should be licensed and to whom, the stronger is the case that he or she should own the intellectual property rights. Further, it is not clear that the inventor could not find a technology licensing and marketing organization in the open market.

Calabresi and Melamed (1972) argue that entitlements should be given to the party that can best make use of them, but if it is the case that parties can bargain costlessly, then any error in this assignment will be corrected. When we allow that transactions are costly, assignment matters and an error can have efficiency effects as well as distributional effects. The most effective exploiter of an invention could be either the inventor or the TLO, depending on the nature of the invention, but this advantage cannot be known a priori. If transactions costs and time loss between the inventor and TLO are low, a mistake in property right assignment will be corrected with the party placing the highest value on the invention bargaining for that right. But if transactions costs and/or time loss is important, then a mistaken assignment should result in economic loss.

Existing research models the TLOs as having perfect information and occupying a high stage of competency thus allowing them to make informed and prescient decisions (e.g., Thursby et al., 2007).<sup>17</sup> This assumption allows economic models to be tractable;

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<sup>17</sup> Basing economic models on assumptions that the actors are consummate and never make mistakes is necessary for modeling, but in reality most actors are only average and thus make significant numbers of mistakes.

unfortunately, it is also unrealistic. At the invention stage, the strategic questions usually arise from uncertainty—e.g., will the technology work in practice, is there a market if it works, who should commercialize the technology, and will it be profitable? These questions are unanswerable *ex ante*. In the normal case, the inventor is most likely to understand the technology and its potential the best.

It is reasonable to believe that there is an asymmetry in transaction costs between the university inventor and the TLO. Suppose a TLO represents the most effective vehicle for exploitation, but that the entitlement resides with the inventor. How will these parties react? Both will most likely realize that the TLO is the most effective manager of the invention, and the inventor will either sell the rights to the invention to the TLO or contract the TLO services. In this case the gains from these transactions exceed their costs, and the economically efficient result of TLO management is achieved. Notice this judgment does not occur when the TLO receives automatic ownership. Of course, the TLO could also make such a judgment, but it has an inferior understanding of the technology.

Now suppose that the inventor is the most effective innovator but the entitlement has been granted to the TLO. In this case it is hard to see how the inventor can buy the rights to the invention. The only possibility is for the TLO to contract the services of the inventor to help commercialize the invention. This case could be avoided by consistently awarding the rights to the inventor.

The TLO as an organizational form was born schizophrenic, torn with contradictions, and hard-to-fulfill mandates. An examination of these problems makes it possible to understand why TLOs, regardless of whether they are well-managed, occupy

a conflicted position in any technology commercialization process. The research by Owen-Smith and Powell (2001) provide an excellent comparison of TLOs at the two research universities. The well-managed one at an entrepreneurial private university, operated smoothly with considerable success. The one at the large public university had far greater management difficulties. Obviously, a badly managed TLO can impede technology transfer. For example, Colyvas et al. (2002) found in their research at elite universities with presumably excellent TLOs, one case in which the TLO's desire to protect the university interest in an invention complicated the transfer process. There are many rumors and anecdotes about other cases in which the needs of the TLO to protect its proprietary position complicated or retarded transfer.

The role of the TLO is to monetize inventions. Under normal circumstances it negotiates a sale of rights to a commercial party. This party, because they deal with the specific business area, is likely to have a better understanding of the value of the invention than the TLO has. In addition, they have the possibility of approaching the professor directly for a consulting relationship to organize a technology transfer (Link et al. 2007). So, in relationship to the TLO, the commercial party has superior information and alternatives.

There are other difficulties. Decisions to patent are not made in a vacuum. The TLO may also be the victim of university political decisions. For example, if their invention is not patented and marketed, inventors may threaten to leave taking their laboratory and grants with them. Resignation by professors with large federal grants would lead to the loss of significant overhead income. In an effort to retain individuals, the TLO's superiors may demand favorable decisions. This tactic is particularly true

when the TLO reports to administrators having little understanding of and sympathy for business and technology licensing issues.

In the cases in which the inventor wants to form a firm to exploit the invention, there is near certainty that the professor's interests will diverge from the interests of a profit-maximizing TLO and converge with that of the licensee, the professor's firm. In fact, Markman et al. (2005a) found that the most "attractive" combinations of technology stage and licensing strategy for new venture creation, i.e., early stage technology, combined with licensing for equity, was the least likely to be favored by the university. This improbability was fostered because many university TLOs are focused on short-term cash maximization, and they adopt the characteristics of the risk-averse university bureaucracies with which they are embedded. This scenario is quite natural in situations where there is a significant information asymmetry with the TLO in the inferior position because the inventor is now both an inventor and the licensee.

The likely response of any agent in a situation where other parties to the negotiation have superior information, and possibly back channels for commercialization, is to hesitate. Hesitation until more information is available becomes the dominant strategy. In cases in which the TLO is risk-averse, then the instinct to hesitate will be even more compelling. Since the TLO has ownership, procrastination has no direct costs, though there may be enormous (but often unknown at the time) opportunity costs. Should the TLO act hastily, the outcome is likely to be a suboptimal for the university and often the inventor. The costs for the TLO are often reputational. If the inventor has superior information, which is likely since the inventor is knowledgeable about the field, then the

inventor may lose faith in the licensing office and refuse to cooperate in the technology transfer process.

Academic models of TLO operation are invariably static. However, as it operates, a TLO acquires a reputation that affects future operation (Owen-Smith and Powell 2001).<sup>18</sup> A positive reputation for managerial excellence encourages trust on the part of the inventor and the licensee, thereby overcoming the confrontational/positional problem. However, when difficulties are experienced by either the inventors or the licensees, a negative reputation effect ensues decreasing trust. Inventor communities in universities are characterized by high levels of communication (Bercowitz and Feldman 2008), and the subjective experiences of inventors with the TLO are certain to be communicated to others.

The costs to the university of a negative experience by the inventor/entrepreneur can be enormous. For example, the positive experience of James Clark—then a professor at Stanford University when he left in 1982 to form Silicon Graphics to exploit the fruits of his university research—was explicitly mentioned in his 1999 decision to donate \$150 million to Stanford (Capart and Sandelin 2004). The negative experience of Marc Andreessen, one of the original developers of the Mosaic browser while a student at the University of Illinois illustrates the dangers of a negative licensing experience. When Andreessen joined James Clark to form Netscape in 1994, they attempted to negotiate a license with the University of Illinois but found the process so frustrating that they ultimately entirely rewrote the browser code. By 1999 the University of Illinois had successfully collected \$7 million from the Mosaic copyrights, but the ill feelings of the Netscape founders, cost the university a far greater amount in lost donations (Kesan and

Shah 2004: ff454; Reid 1997: 37). To administer a TLO that frustrates entrepreneurs through difficult financial and contractual demands is likely to be costly in terms of future donations that often far outweigh the gains from licensing.

If the TLO is not well-managed or so small that it lacks sufficient personnel qualified in the specific technology underlying the disclosure, the result is often a risk-adverse bureaucracy frustrating technology transfer and fostering the cumulative development of a negative reputation. TLOs are biased toward caution, high initial payments, and the imposition of constraints on licensees. Some TLOs have reputations for being difficult or incompetent; thus they are either shunned or approached by potential licensees adversarially (Owen-Smith and Powell 2001). TLOs may develop adversarial relationships with the faculty discouraging further disclosures, contribution to patent maintenance and extension, and participation in the transfer process so necessary for the licensee to monetize the invention. A reputation for adversarialism encourages inventor circumvention of university regulation through the transference of inventions to off-campus entities outside the official disclosure system. Considering the TLO as a necessary institution for technology transfer is not based in fact and is not theoretically sustainable.

### *Metrics as a Solution*

To address TLO problems, some economists believe that appropriate metrics could be developed to induce improved performance. The objective of metrics is to motivate optimization on the measurement criteria. For this reason, metrics must be designed to incent desired conduct. Obviously, in the decentralized U.S. university

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<sup>18</sup> For an exhaustive discussion of the economics of reputation, see Cabral (2005).

system, universities will fashion different metrics to motivate desired behavior. The obvious and dominant metric is to measure the difference between annual revenues and costs, i.e., net revenue. The natural response to this metric is maximization of up-front licensing fees and discounting future royalty streams. This approach rewards aggressive bargaining and patent troll-like strategies. It encourages TLOs to develop “submarine” patents,<sup>19</sup> such as Columbia University’s secret efforts to extend the Axel transformation patents through a clever strategy of asking for Patent Office continuations, and then getting the patent issued immediately prior to the initial patent expiration (*Harvard Journal of Law and Technology* 2004).<sup>20</sup> This strategy demonstrates that Columbia’s TLO is a revenue-maximizing organization. Contributions to global welfare and knowledge transfer are not the objective.

Other metrics suggested include measuring the number of patents filed. This metric would reward prolific patenting, and likely would be of greater cost than value. It would encourage TLO officials to dun researchers for more disclosures, thereby diverting their attention from their primary purpose, which is research. In Addition, patenting is expensive and, since many patents are never used, such a strategy might raise costs without increasing revenues.

Adopting the appropriate metric is difficult due to the contradictory position of the TLO. Although its ideal role is to enable technology transfer, its de facto purpose is to generate free cash flow. If the only measure of TLO success is indicated by revenues,

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<sup>19</sup> A “submarine” patent is an informal term for a patent first published and granted long after the original application was filed. In these cases, the knowledge users may have invested significant sums without the knowledge that there was firm that had a patent on knowledge. These patents violate one of the fundamental goals of the patent system, which is to make the knowledge public so that others can be aware of it. When the submarine patent finally emerges, other users may have made significant investments that can be held hostage by the patent owner.

then it will inhibit other purposes. With revenues as the measure, there is a default imperative to bargain tenaciously and demand up-front payments, thereby increasing the licensee's risk. Given that the potential licensee has greater knowledge than the TLO representative, uninformed positions on the part of the TLO representative are likely to frustrate negotiations. If the licensee is the inventor, then a negative reaction is likely. For the inventor-licensee, dealing with the TLO can be frustrating. If the purpose is technology transfer, then such dysfunctionality, which always threatens to occur because of the institutional position of the TLO, results in a pronounced tendency towards suboptimal outcomes.

If a TLO is measured in terms of revenue, then its emphasis naturally shifts to extraction of the greatest amount from licensees. Because nearly every university is based on annual budgets,<sup>21</sup> the dominant strategy would be to favor up-front payments from deep-pocketed large firms and pursue aggressively only those inventions that the technology licensing officers believed had the greatest potential pay-off (Lemley 2007).<sup>22</sup> Concentrating on only inventions with clear pay-offs could inadvertently limit the spin-off of university research. In a study of the commercialization of university-derived inventions in electron microscopy to small startup firms, Cyrus Mody (2006: 80) concluded that “policy-makers cannot predict which [research] communities will generate profits, and will hinder all if they try to encourage only profitable ones at the expense of the rest.” The structural conditions suggest that even if the TLO does not

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<sup>20</sup> This example is even more interesting because Columbia University lobbied a U.S. senator to add an amendment extending the Axel patents (*Harvard Journal of Law and Technology* 2004: 596).

<sup>21</sup> It should be noted that TLOs that have had enormous success and strong cash flows might be more likely to make longer term investments, though again with the goal of maximizing their incomes.

<sup>22</sup> Predicting in advance the pay-off from a new invention is very difficult. For example, Katharine Ku (2008) has stated that they “did not know Google would be successful at its inception or that the technology was particularly revolutionary.”



believe there are commercial opportunities, it does not follow that it will return the rights to the inventors. The rational bureaucratic response would be to delay action until the true value became clearer – something that the provisional patent mechanism encourages. Obviously, this delay would retard the technology transfer process.

The existing TLO model is fraught with information asymmetries, agency problems, and contradictions. Where consummate practitioners operate the TLO, they can overcome these contradictions using their success and reputational effects they created or inherited. Unfortunately, the structural situation leads to risk aversion and temporizing. Recent recommendations that TLO managers be provided with incentive pay (Link et al. 2007) is likely to lead to increased short-termism with high up-front licensing fees discouraging entrepreneurship and encouraging greater aggressiveness on the part of the managers in encouraging/demanding disclosure. The current TLO model based on automatic ownership is not justifiable and, in most institutions, it operates solely to generate the greatest revenue for the university administration.

### *The Inventor*

The reasons humans invent are complicated and differ among individuals (Basalla 1988). The university environment is chosen by many researchers because of its relatively unstructured and collegial environment, but at the cost of relatively inferior compensation.<sup>23</sup> As we discussed earlier, academic researchers are not managed by the administration in the same way as a corporation would manage them. Further, though there are requirements that researchers disclose and assign their inventions to the university, these rules are not easily monitored or enforced (Siegel et al. 2003).

The literature suggests that the best way to encourage disclosure on the part of university employees is to increase their royalty rates. Lower royalty rates, though, tend to encourage firm formation (DiGregorio and Shane 2003). This tendency implies that researchers are sensitive to the opportunity costs of forming their own startup. It is assumed that the university inventors are necessarily motivated by receiving as high a royalty as possible.<sup>24</sup> However, when the inventor has a significant financial stake in the firm licensing the technology, royalties diminish the firm's profit, thereby making it less profitable. This affiliation creates powerful contradictory motives for the inventor.

When an inventor participates in the TLO process, there may be difficulties if the inventor believes, rightly or wrongly, that the TLO is insufficiently aggressive or generating insufficient income. This deficiency can become acute if the inventor comes to believe that the TLO is investing insufficient resources in their invention or that the TLO is incompetent. In the case of prior disclosures, the inventor has little recourse. However, for new inventions, given the conditions of the inventor's employment described earlier and the specifics of the new inventions, alternatives to disclosure exist. What is significant here is that in contrast to a firm where there presumably is much greater monitoring of researchers, the university is organizationally unable to supervise strictly without violating its charter and desirability as an employer.

Organizationally, securing intellectual property for a university is difficult for a variety of reasons. Recently, scholars have noticed that many professors have established firms or developed intimate relationships (very often including tangible economic

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<sup>23</sup> Outside some of the elite corporate R&D laboratories, corporate researchers are more product oriented.

<sup>24</sup> At each university the inventor's royalties are calculated according to different formulas. For example, the University of California website states that an inventor receives 35 percent of the net income after the direct costs of administering an invention are subtracted from the gross income. Of course, the calculation of the direct costs is

incentives) with firms undertaking research and development (R&D) in fields closely allied with their university research. This phenomenon is described as being a “gray market” for inventions (Markman et al. 2006; Mody 2006: 79). The dimensions of the gray market are difficult to ascertain, but it is likely to be substantial. From a sample of National Institutes of Health, National Cancer Institute grantees, David Audretsch et al. (2006) found that in their field of expertise 20 percent of the professors had established firms without university licenses. An inventor has many options for circumventing the university TLO. For example, it is possible to establish a firm prior to generating a patentable invention and then transfer the “discovery” of a valuable molecule to the firm. This shift is not difficult to arrange because the tacit knowledge can be transferred through a graduate or postdoctoral student joining the firm. The university researcher can then serve on the scientific advisory board to realize the transfer process. Policing such strategies is difficult, placing the TLO in the position of investigating a university faculty member and possibly catalyzing an embarrassing situation.

In computer science and other engineering disciplines, transferring inventions is usually easy, as the invention need not have occurred in the laboratory, and there is less written evidence such as laboratory notebooks to establish the genesis of invention. The inventor can resign from the university making it difficult to establish the provenance of the invention and therefore assert control. A motivated inventor has ample opportunity and means for circumventing the university’s claim upon the invention.

A variant on the gray market strategy is to publish the invention vitiating the possibility of a patent. Given that the inventor has superior knowledge, it may be

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difficult, and thus it can create controversy. The University of California, as a state-funded institution, is required to pay 25 percent of its licensing income to the State of California General Fund.

possible to found a firm to exploit the invention. Again, this strategy is likely to be easiest in engineering and particularly computer science, but it may also be possible in biomedical and scientific instruments (Mody 2006). In therapeutics, where there is a significant paper trail of laboratory notebooks and various laboratory employees who would be aware of the invention's provenance, patents are of greater importance for protecting the invention and raising venture capital.

Inventors might also disclose the invention, and then provide no further cooperation with the TLO. In such cases the TLO has little leverage to compel cooperation even for preparing a patent application. Non-cooperation would ensure that licensing would be difficult and might lead to the TLO providing a low-cost license to the inventor. The costs of non-cooperation are likely to be low for tenured professors, but they could be more severe for either a non-tenured professor or researcher.

The situation of the inventors is curious from an economic perspective. First, they are employees of the university and therefore legally obligated to disclose any inventions. And yet, enforcement of this obligation is difficult. The academic literature recognizes this and suggests greater rewards to entice disclosure. Some have suggested that university inventors be rewarded for disclosure in the academic personnel system. Put differently, they are suggesting that the university be at least partially converted into an "invention shop" where inventors receive not only a share of the royalties, but also that invention and disclosure become integrated into the core mission of the university despite the fact that, as we have shown, the current TLO model is an inefficient and ineffective model for commercializing university inventions.

## **Possible Solutions**

Given the contradictions, misaligned incentives, and inefficiencies inherent in the extant model of ceding ownership of employee inventions to the university, we propose that two entirely new models should be considered. The first model accepts the premise that invention ownership is necessary to create the maximum social good. The strongest argument for the importance of patenting in technology transfer is for therapeutic molecules in the pharmaceutical industry. The crux of this argument is that the enormous costs of securing regulatory approval requires exclusive rights to sell the pharmaceutical to recoup investment. Acceptance of this proposition, though, does not answer the question of whether the university or the inventor would be the best owner of the patent rights.

We suggest that ownership be vested in the inventor, exactly the individual able best to understand the invention, its potential, and most likely to have ideas for potential customers. The second model is more radical. In this model, all university inventions would be treated as open source and would be made available to all users. There would be no TLO. The university would be removed from direct control of the technology transfer process and return to its role as a platform for research and instruction.

### *Inventor Ownership*

The first model vests the rights in the inventor who, as we already have shown, is most likely to have the best information (see Litan et al. 2007). This model is already a possibility. Pat K. Chew (1992) found that federal sponsors allow inventors' title to inventions that universities decline to exploit. If inventors owned the rights, then they

could choose to use the university TLO or any other organization to commercialize the technology, commercialize the technology themselves, or make the invention public. The transfer of the ownership rights to the inventors would make them the principal, and they could secure an agent. University TLOs could operate as agents. The principal would judge them by their service level giving them a strong incentive to provide excellent service. The TLO would benefit in that it would be relieved of the pressure to manage inventions that have little prospect of success, but for which the TLO has responsibility. Altering the power relationship would force TLOs to operate as service organizations and alter the relationship from one structured to serve the TLO to one structured to serve the inventor-owner. A successful TLO would meet the needs of its principal, the inventor.

TLOs would either become self-supporting or discontinue operation. Though some university TLOs might not survive, their location on campus provides them with a strong advantage. Faculty inventors not wishing to expend time and effort on commercializing their inventions would normally turn to their local TLO. These were exactly the conditions that Niels Reimers faced when he established the Stanford TLO and filed the Cohen-Boyer patent.

Beyond the efficiencies, the institution of an inventor-owned patent regime would remove the temptation to judge faculty on the basis of the financial return they can provide the university. Some researchers allying themselves with the acquisitive university administration's perspective have concluded that professors lack sufficient incentive to disclose inventions, and that "it also seems prudent for universities that place a high priority on formal technology transfer to place a higher value on patenting, licensing, and start-up formation in promotion and tenure decisions" (Link et al. 2007).

These authors are suggesting a wholesale transformation of the incentive structure of the university to suit the needs of the theoretically and conceptually flawed current TLO model. In other words, they wish research, teaching, and contributions to the general societal knowledge pool to vie with patent generation and firm formation as a university goal. What has been a minor part of the university and an insignificant source of funds is by these authors raised to a central goal of the university—and this without any evidence that such radical action would be socially desirable or that it would generate greater economic activity. This is a recipe for keeping second-tier research universities second-tier and transforming first-tier research universities into a probably unsuccessful hybrid of corporate contractor and small firm incubator.

Transferring the property rights to the inventor does raise normative questions regarding the propriety of allowing individuals to capture the entire benefit from inventions developed with public monies in the social space of the university commons. In our pursuit of efficiency and effectiveness, it is possible to argue that we have violated norms of fairness. This objection could be addressed through employment contracts that provide for the university to receive a tithe from its inventors of, for illustration purposes, five percent of the equity or licensing proceeds of any invention a university researcher makes in their field of expertise. Notice such a contract would dramatically circumscribe the burgeoning gray market that vexes the current disclosure regime, while being so small so as not to discourage inventor commercialization. Put simply, addressing normative issues is not precluded by the movement to a regime that is more effective and efficient.

The university administration's role under inventor ownership would not change—it would continue to ensure that faculty exploiting their inventions would

discharge their institutional duties. Inventor ownership might increase secrecy and the exploitation of students, but there is no evident reason that these negative relations would be any worse than they are today—and the administration would not be complicit. If such problems were a concern, then faculty members could be required to report efforts to exploit university-related (or even all) inventions they were commercializing. This model would create greater transparency and remove the problems of gray markets. Furthermore, it does not generate any serious new problems, while it does address the current difficulties and inefficiencies.

### *Open Source Invention*<sup>25</sup>

A more radical model would be for the federal government to mandate that all inventions generated through federal support be de jure placed in the public domain. This model resembles that of Richard Nelson (2003) except that he suggests universities should extend non-exclusive licenses in an effort to preserve the scientific commons. Since non-exclusive licensing is merely a “tax” and shifts of the invention rents from one actor to another, our recommendation goes further by shifting the rents themselves into the commons. The inspiration is the very successful Open Source software movement predicated upon an even more radical “commons” model (Rhoten and Powell 2007). For basic process innovations, even in biology, such an “open” strategy is likely to be as effective or even more effective than either exclusive or non-exclusive licensing in encouraging technological transfer and progress. In many engineering-based technologies, patents are not normally considered to be of great significance except to ensure cross licensing (Cohen et al. 2000; Mansfield 1986). The greatest concern in a



non-patenting regime would be for proprietary pharmaceutical compounds that might not be developed absent exclusive patent protection (Levin et al. 1987; Mansfield et al. 1981). Even here there have been alternatives. For example, there were no patents on the anti-cancer drug Taxol molecule, and yet it was successfully commercialized (U.S. General Accounting Office 2003). The Taxol example suggests that the belief in the exceptional nature of pharmaceutical compounds might not be as certain as many believe.

It is possible that, absent patent rights, small biotechnology firms might not be able to compete with the large established pharmaceutical firms having many complementary assets, thereby limiting entrepreneurial startups based upon university biological science.<sup>26</sup> This constraint could result in less entrepreneurship, and a possible social loss. And yet, large established pharmaceutical firms are retrenching R&D with the intention of buying promising drug candidates from venture capital-financed firms. If this is the case, then university patents might not be that critical to small firm entrepreneurship. Alternatively, once the knowledge is in the commons, it is possible for young firms to internalize this knowledge and create new businesses. For example, open source software has lowered the cost of entry for information technology entrepreneurs. Whether the IT model would work equally well in pharmaceuticals is less certain.

The elimination of patenting of federally funded research would be an affirmation of faith that markets and entrepreneurs can capture the value of new knowledge through a process of making the knowledge commons larger rather than restricting it. For the university, this trust would eliminate the current concerns about commercialization impacting its mission or unduly influencing faculty, though a gray market still might

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<sup>25</sup> For an extended discussion of this, see Rhoten and Powell (2007).

appear. Open source would lower the cost and uncertainty of using new university-developed technologies and thereby accelerate their adoption. Though a radical response to the difficulties of the current regime, considering an open source model provides a real world reference point for considering other university patenting regimes and thus might lead to better solutions than using the unrealistic “perfect world” models underlying most economic models.

## **Conclusion**

Today, TLOs have become self-perpetuating bureaucratic organizations. We have demonstrated that, for the vast majority of inventions, the TLOs do not encourage any better technology transfer than would have occurred without any intermediary organization. In fact, the aggressive, and apparently questionable, patenting and prosecution of the human stem cell patents by the University of Wisconsin, Madison, has retarded adoption. Human stem cells, as an enabling technology, would be used regardless of whether they were patented or not. This example highlights the potential for a socially non-optimal outcome from the current university technology transfer regime. In essence, the University of Wisconsin, Madison, has an intermediary operating as a for-profit firm. The public policy question raised is whether in their current aggressive management of intellectual property, U.S. universities should be treated as for-profit entities. We have demonstrated that it is unsustainable to claim that TLOs facilitate commercial knowledge transfers through licensing patents resulting from university research.

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<sup>26</sup> On complementary assets, see Teece (1986). In the case of pharmaceutical and biotechnology firms, see Rothaermel (2001).

The advocates of mandatory disclosure and TLO ownership, some of whom have gone so far as suggest the inclusion of faculty patenting and commercialization as part of university promotion schemes, are conflating an indirect benefit of research with the goals of an institution. Many do not give credence to serendipity in the invention and commercialization process. We agree with Cyrus Mody's (2006) conclusion that new firms have their roots in a university's institutional arrangements, but not in the patent and TLO regime favored by most proponents of academic entrepreneurialism (See also Colyvas et al. 2002).

In this paper we argued that the current institutional arrangements implemented under the B-D TLO patenting system are flawed at the microlevel. In a future paper, we will examine how this microlevel operationalization is linked to the interest group pleadings in Washington, D.C., by the professional organization for TLO managers, the Association of University Technology Managers.<sup>27</sup> Before Congress, AUTM, and TLO employees from various universities represent themselves as speaking for the university and lobby for an ever more restrictive patent regime that is inhibiting innovation and commerce (Jaffe and Lerner 2004).<sup>28</sup> This political position is the direct result of the university's status as a non-profit organization and structural inability to commercialize inventions directly. For this reason, university TLOs find their economic interests aligned with and, in specific cases, operate as what have been pejoratively termed "patent trolls."<sup>29</sup>

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<sup>27</sup> A classic explanation of interest group politics is Lowi (1979).

<sup>28</sup> Jaffe and Lerner (2004) is a detailed indictment of what they believe is a patent regime that is too tilted in favor of the patent holders.

<sup>29</sup> For a discussion, see De Larena (2006).

This paper questioned academic and public policy discourse on how universities should handle inventions. It is remarkable that, despite a veritable outpouring of academic research on technology transfer from the university, the fundamental theoretical and conceptual issues regarding the role and operation of TLOs have until very recently been ignored (for exceptions, see Litan et al. 2007; Powell et al. 2007). Contemporary academic studies are replete with admiration for B-D and ask few critical questions.<sup>30</sup> Given this near unanimity of uncritical adulation, it is not surprising that leading global organizations such as the OECD (2003) state that “one of the most urgent tasks is still to raise awareness of and support for university patenting and related activities.” The recent academic literature and popular press attribute a powerful positive role in technology transfer and university-staff entrepreneurship to university TLO ownership of inventions. This attribution has preempted scholars from asking difficult questions about how to optimize the contributions of the university to society and the economy.

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<sup>30</sup> There is an entire methodological literature in anthropology dealing with the dangers of over-identification with research subjects to the point at which one loses one’s critical faculties. This can lead to the adoption of the subject’s worldview, at the expense of a more detached scientific perspective.

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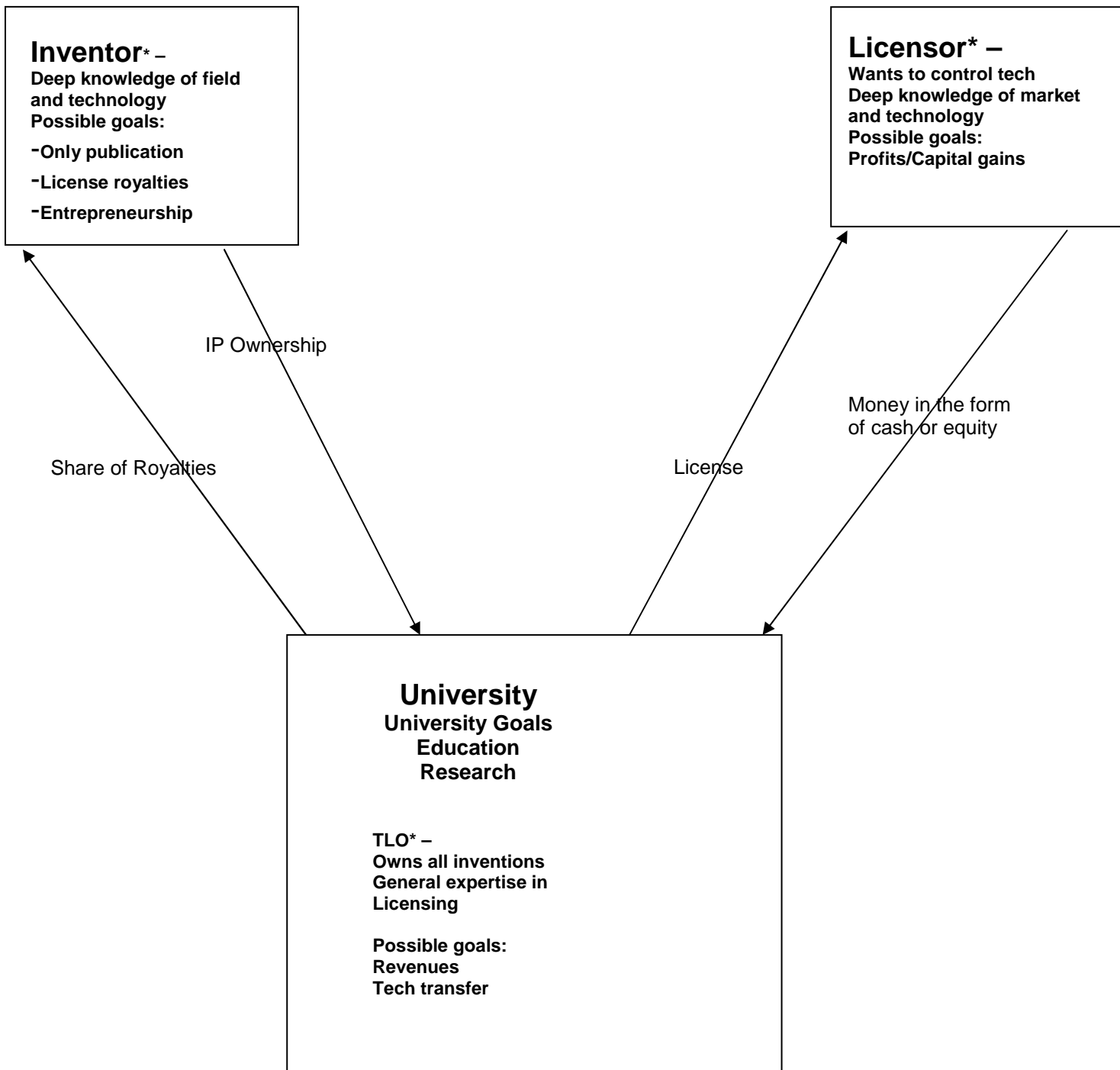
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# Schematic of the Actors in University Tech Transfer Relationship

The inventor and licensor can be one and same



\* In this diagram we assume the inventor is a professor

For a somewhat different formulation of this relationship, see Siegel et al. (2003).

Table 1: Selected Ohio State University Technologies Listed on Website as Available for Licensing

<b>Technology</b>	<b>Field</b>	<b>Number in Field*</b>
Heart Healthy Soy Bread	Agricultural Sciences and Food Technology	30
A Real-Time RT-PCR Assay for the rapid detection of Very Virulent Infectious Bursal Disease Virus (vvIB-DV) Strains	Agricultural Sciences and Food Technology	30
Altering shape morphology of fruits	Agricultural Sciences and Food Technology	30
Differentially Expressed in Squamous Cell Carcinoma Gene 1 (DESC 1)	Biomedical Research Tools	7
A Gas-Assisted Resin Injection Technique for Bonding and Surface Modification of Microfluidic Devices	Chemical Engineering and Manufacturing	26
High Temperature NOx Sensor	Chemical Engineering and Manufacturing	26
Remote Controlled Patterning of Watering Area by Retrofitting Sprinkler Heads	Civil Engineering	4
Method for Dynamic 3D Wavelet Transform for Video Compression	Computing and Communications	5
Branched apogenic peptide for inducing apoptosis	Drug Discovery and Therapeutics	39
Dual band cellular/GPS semicircular loop slot in metal film	Electronics and Optronics	11
Organic Light-Emitting Diodes (OLED) for Solid State Lighting	Energy and Environment	15
Multiwell Microprocessing Basket	General Instrumentation	8
Fabrication of Micro-devices with Sandwich Structure	Materials and Nanotechnology	19
Dentin Anchor	Medical Devices	23
Development of high affinity aptamers that bind to 23-89 residues	Medical Diagnostics	14
Method for Accurate Pitch Estimation and Voice Separation	Security and Identification	4
Neurodynamic Algorithm for Design Automation & Optimization (NeuroAutoOpt)	Software and Databases	3
Localized Arc Filament Plasma Actuators for Noise Mitigation and Mixing Enhancement	Transportation	4
Antagonist for Human Prolactin	Veterinary Medicine	10

\* May be listed in more than one category

Source: Ohio State University (January 11, 2008) <http://tlc.osu.edu/technologies/>

