

**Reconsidering the Bayh-Dole Act and the
Current University Invention Ownership Model***

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ABSTRACT

The current model within which universities own the inventions made by their researchers was enshrined in the Bayh-Dole Act of 1980. This paper finds that the current system, in which universities maintain de jure ownership of inventions, is not optimal either in terms of economic efficiency or in advancing the social interest of rapidly commercializing technology and encouraging entrepreneurship. We demonstrate that this model is plagued by ineffective incentives, information asymmetries, and contradictory motivations for the university, the inventors, potential licensees, and university technology licensing offices (TLOs). We suggest that these structural uncertainties lead to delays in licensing, misaligned incentives among parties, and delays in the flow of scientific information and the materials necessary for scientific progress. The institutional arrangements within which TLOs are embedded have encouraged some of them to become revenue maximizers.

We suggest two invention ownership models as superior alternatives to the conventional model. The first alternative is to vest ownership with the inventor, who could choose the commercialization path for the invention. For this privilege the inventor would provide the university 5 percent ownership stake in any returns to the invention. The inventor would be free to contract with the university TLO or any other entity that might assist in commercialization. The second alternative discussed is to make all inventions immediately publicly available through an open source strategy or, through a requirement that all inventions be licensed non-exclusively. Both alternatives would address the current dysfunctional arrangements in licensing university technology .

The belief that the commercialization of federally-funded research results was retarded by the federal ownership of the intellectual property rights led Congress to pass the Bayh-Dole Act (B-D) in 1980.¹ Based on minimal evidence, it was believed that government-owned patents were insufficiently utilized (Eisenberg 1996). B-D standardized the procedures for vesting the control of federally-funded research inventions in contractors, including universities (Mowery et al. 2004; Slaughter and Rhoades 2004). The popular press and others hailed the model of university ownership of these inventions as a boon to society (e.g., *The Economist* 2005; OECD 2003). In recent years there have been an increasing number of critiques (Glenna et al. 2007; Nelson 2004; Washburn 2005, and, in particular, Litan et al. 2007) and complaints from faculty inventors and potential licensees concerning the current model.

In the name of providing the fruits of university inventions to society in an efficient, effective, and socially optimal manner,² Congress designed the B-D Act so that universities could claim title to inventions made as a result of federally-funded research. The growing commercial interface between the university and industry has sparked an outpouring of research (for reviews, see Rothaermel et al. 2007; Shane 2004). Questioning the B-D model is important not only for the United States, but also because a process of global organization mimesis is underway (on mimesis, see DiMaggio and Powell 1983), as other nations adopt B-D-like models patterned in the belief that it is the best way to ensure the commercialization of university inventions (Geuna and Nesta 2006; Mowery and Sampat 2005).

¹ Most elite research universities already had Institutional Patent Agreements with various federal funding agents, though these varied by agency. Eliminating this variation was another important goal of the legislation (Mowery et al. 2004).

Although possibly justified at the time, we show through an analysis of the structural position, property rights, and actor incentives that the current B-D-based university invention ownership model results in suboptimal outcomes. This paper explores these difficulties in detail and suggests that research on science and technology policy consider the implications of two quite different remedies for the current inefficiency. Litan et al. proposed the first remedy (2007), namely, vesting ownership in the inventor.³ The second remedy, which has received greater research attention, is to designate all university inventions as “open source” and part of the intellectual commons (Dasgupta and David 1994; Rai 2005; Rhoten and Powell 2007).

Drawing upon the now substantial body of literature on the operation of university TLOs, technology licensing, and university-industry relationships, more generally, we build most directly upon the contributions of three different research traditions. The first tradition, for lack of a better term, is evolutionary institutional economics pioneered by Sidney Winter and Richard Nelson and includes Wesley Cohen, David Mowery, Nathan Rosenberg, and their students. They examined the historical evolution of the current university ownership model and found that it is having a discernable, though debatable in terms of importance, effect on the scientific enterprise (see Mowery et al. 2004; Cohen et al. 2000). The second tradition that has framed our thinking represents the sociological network analysts roughly grouped around Walter W. Powell. Although less overtly concerned with the institutional and social impacts on the university or efficiency, their detailed research on the network linkages between university and industry and the role of TLOs has led them to hypothesize that there is a hybridization of researchers in these two

² We define efficiency, as accomplishing a task in the most rapid, least resource intensive manner possible.

³ On inventor ownership, also see Greenbaum and Scott (2008)

different institutions (Owen-Smith 2003; Rhoten and Powell 2007). The final tradition that informs this paper is the legal tradition questioning the current university invention licensing model (Eisenberg 1996; Lemley 2007; Rai and Eisenberg 2003). Though inspired by these perspectives, this paper moves in a different direction by showing that the current university invention ownership model is plagued by ineffective incentives, information asymmetries, and contradictory goals for inventors, potential licensees, the university, and university technology licensing offices (TLOs).⁴ These structural uncertainties lead to commercialization delays, unnecessary expenses, “gray” markets in inventions, unenforceable restrictions on inventors, misaligned incentives among parties, and delays in the flow of scientific information and the materials necessary for scientific progress. A state of affairs that exists even though there are simpler and more effective alternatives.

The paper begins with a brief background to B-D, the current university ownership model and criticisms thereof. The second section examines whether TLO behavior comports with the claim of facilitating technology transfer. This is followed by an analysis of the TLO-inventor relationship describing the contradictory goals, information asymmetries, and perverse incentives resulting from the university ownership model. The penultimate section examines two alternative models. In the first model, invention ownership is vested in the inventor. In the second model, all inventions are placed in the public domain. The concluding discussion summarizes our analysis of the

⁴ 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 (2006). For an excellent review of the literature on university-based entrepreneurship, see Rothaermel et al. (2007).

current implementation of the B-D Act and the implications of adopting either of our alternative schemes.

Background

The congressional motivation in passing B-D emanated from the proposition 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). There was also a belief that the university could be the source of innovations that would reinforce U.S. economic preeminence (Brooks 2003; Stevens 2004). B-D granted property rights to the inventions to federal contractors, including universities.⁵ The public policy objective was to incent the transfer of the benefits of federally funded research to society. In many cases, universities, as a condition of employment, had already claimed employees' inventions. With the rights to inventions made with federal funding came an affirmative obligation to market them actively (Eisenberg 1996; Mowery et al. 2004; Sampat 2006). The implicit conceptual model held that universities would be sufficiently self-interested to respond to the offer of invention ownership and market the inventions to industry (Rafferty 2008).

As with much legislation, B-D was the result of lobbying efforts by interested parties – in this case, corporations and university licensing officials hoping to monetize these inventions (Eisenberg 1996: 1726; Washburn 2005; Sandelin 2007). For the universities, the desire to appropriate the fruits of their employees' federally-funded research was undoubtedly fueled by the emergence of the biotechnology industry, whose

⁵ The Federal government retained a royalty-free, non-exclusive license.

promise of riches to invention owners culminated with the spectacular 1980 Genentech initial public offering (Kenney 1986).

These riches seemed attainable since patents in pharmaceuticals are more easily defended than in other fields, and therefore particularly well suited to monetization by research-only organizations such as universities.⁶ As an organization, despite the long-running debates on the penetration of commercial concerns (Bok 2003; Etzkowitz 2002; Kenney 1986; Krinsky 2003; Slaughter and Leslie 1997; Washburn 2005), 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 educating future citizens and workers, and conducting research to advance knowledge. A third motive is less precisely defined and is the diffuse idea of providing service to society. None of these motives is easily measured by profit, and there is the constant necessity to balance these often congruent, but sometimes contradictory, motives.

At the time B-D was passed, far fewer university researchers particularly in biology had an interest in commercializing inventions. This ethos eroded in the early 1980s as biology, the largest recipient of federal funding, underwent a technical and commercial revolution making research results more commercializable and, in certain cases, quite lucrative (for an extended treatment of this period, see Kenney 1986; also Jong 2006 and Colyvas 2007). In engineering and chemistry there was a long history of commercialization of university inventions, although largely through individual faculty efforts and the Research Corporation (for more see, Mowery et al. 2004 Chapters Two and Three). In many respects B-D was a formalization of an extant movement, but it

served to alert faculty and administrators still operating under the previous more Mertonian social ethos that conditions were changing, and it was socially desirable for university researchers to patent inventions. With visions of a new income source, universities that did not have a TLO soon established one.

Is a TLO Needed for Technology Transfer?

Universities have a long history of generating inventions having commercial value and having these used by industry (e.g., Geiger 2004; Mowery and Sampat 2001; Rosenberg and Nelson 1994). Since universities cannot produce goods for sale, they depend upon patent protection. And yet, it is only since the 1970s that TLOs dedicated to commercializing inventions have become commonplace at research universities (Mowery et al 2004).

One unique feature of universities is that they have a far greater variety of inventions than does any private sector firm. The patent literature suggests that the importance of patents differs by industry (Levin, Klevorick et al. 1987). For example, in electronics, software, and engineering, patents are most often used defensively to ward off infringement cases from other firms, though this may be changing (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), and, for example, Stanford University has often used non-exclusive licenses (Ku 2002). If one considers university-affiliated information technology (IT) startups during the last three decades,

⁶ 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

some did not have university licenses, such as 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 procure licenses. What is not clear is that TLO involvement was necessary for adoption. If TLOs may not have been vital 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).

Critical case studies provide insight into the significance of TLOs for technology transfer. The most studied and one of the most valuable university patents ever issued, the Cohen-Boyer (C-B) patent, serves well in parsing the centrality of the TLO in technology diffusion. The C-B patent was a process patent issued in 1980 on a pioneering and fundamental technique for the creation of genetically engineering microorganisms (Hughes 2001; Kenney 1986: 258; Powell et al. 2007).⁷ Over its 17-year life, it produced in excess of \$255 million in revenues for Stanford University and the University of California. The vast majority of these were royalties from human therapeutics developed using the engineering technique.

There have been misunderstandings regarding the role of the C-B patent. For example, Maryann Feldman et al. (2007) concluded that “had it not been for Stanford’s enlightened licensing practices, the C-B technology might have been placed in the public domain where the technology could have remained undeveloped or in the laboratories of

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

⁷ According to Reimers and others, Hughes (2001), which is based on interviews with nearly all of the key actors, is a definitive history of the C-B patent.

large established pharmaceutical companies.”⁸ 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 in use at the time of its filing (Reimers as quoted in Sampat 2006). Within months after being revealed at a 1973 Gordon Conference, university laboratories around the world began using the C-B process. The communities of practice within which scientists are embedded ensure that any powerful new tool diffuses almost immediately.⁹ Even if C-B had never been patented, the fact that in 1976 and subsequently the swarm of other newly established firms practiced C-B. This is evidence that the technique would have been adopted regardless of whether it had been patented or not. Since it was licensed non-exclusively, it is a simple economic exercise to demonstrate that payments would, at the margin, discourage usage. The license operates as a tax (for C-B specifically, see Rai and Eisenberg 2003: 300; for a general statement, see Mazzoleni 2006). Reimers understood these marketplace realities and therefore wisely set a low license fee and royalty payments.

A similarly important invention, developed contemporaneously, can provide an alternative perspective. In 1975, while working at Cambridge University, Georges Köhler and César Milstein in a short letter to *Nature* described the invention of what came to be known as monoclonal antibodies (MABs), which rapidly became a widely practiced powerful general-purpose enabling technology.¹⁰ The inventors were aware of its value and explicitly stated in their *Nature* letter that “such cultures could be valuable for medical and industrial use” (quoted in Cambrosio and Keating 1995: 8). Had the

⁸ Of course, once the Cohen-Boyer technology was published, it could no longer have been patented by anyone except the inventors, so it is not possible that a large pharmaceutical firm could have patented the technique.

invention been patented, it would have been a basic patent (Oliver and Liebeskind 2003). In this case, the inventors placed their invention into the public domain.

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.¹¹ Other MAB firms were established and large pharmaceutical firms integrated MAB technology into their tool kit. This diffusion 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. 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 the biotechnology industry. The invention of human stem cell lines is a contemporary example. A number of human stem cell lines were developed at the University of Wisconsin, Madison (UWM), and the patent rights were assigned to the Wisconsin Alumni Research Foundation (WARF), a private entity (Jain and George 2007).¹² Aware that stem cells might have commercial possibilities, WARF designed a licensing agreement to be applied to every user, even university researchers. The licensing agreement stipulated that WARF could “reach” through and demand royalties for any invention using their stem

⁹ For discussion of communities of practice, see Lave and Wenger (1991).

¹⁰ On general purpose technologies, see Bresnahan and Trajtenberg (1996).

¹¹ According to Garnsey (undated), Hybritech was established in 1978 by Ivor Royston, a UCSD professor; Brook Byers, a venture capitalist; and Howard Birndorf, a researcher in Royston’s lab. Royston had been a visiting researcher at Cesar Milstein’s Cambridge lab. After establishing the firm, Brook Byers flew to England to negotiate with the Medical Research Council to license the technology only to discover that it was in the public domain.

cell lines. UWM, through its agent WARF, has a long history extending back to the 1930s of aggressively dunning potential licensees, whether firms or other research institutions (Sampat and Nelson 2002; Rai and Eisenberg 2003). As an illustration, WARF demanded royalties from any related invention by the non-profit California Institute for Regenerative Medicine, which was established by California voters to accelerate stem cell-related research. Under public opinion pressure, WARF withdrew its demand that the California institute pay royalties (WARF 2007). This incident demonstrates that, in this case, income—not technology diffusion —was the overriding goal. WARF, though having non-profit status, operates like a profit-making entity.¹³

Such concerns are echoed in an increasing number of university patents on biological materials, nearly all of which are the result of 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 used] are likely to apply, 29 percent of [material transfer agreements] included a reach-through right and 12 percent included a request for a royalty.” These findings suggest that at least some TLOs, in their search for more licensing revenues, are treating the research enterprise itself as an opportunity to generate revenues.

There is no evidence that technology transfer is the primary goal of university TLOs. In many cases, TLOs are unnecessary for the commercialization of university inventions. Further, at least, some TLOs have become so focused on the pursuit of

¹² It is a common misconception that at the University of Wisconsin inventions belong to the inventor. This is true in cases where the funding for the inventions is not sponsored. If the sponsor is the Federal government all the inventions are the property of the University, which assigns them to WARF.

¹³ One remedy would be for the Internal Revenue Service to decide that WARF and the University of Wisconsin are competing with for-profit patent licensing corporations and withdraw its non-profit status.

licensing revenues that they are willing to tax the research enterprise itself. The evidence, as we will show, suggests that the only transfers most TLOs are interested in are ones from which they can extract licensing fees. To do this they are willing to impede technology “transfer” to unlicensed users. The next section builds upon these findings to suggest that the current ownership-based TLO model is an economically ineffective and inefficient organizational solution for maximizing the social benefits of university-generated inventions.

The Inventor-TLO Relationship

Because of B-D, federally funded inventions 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. 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. This examination elucidates the contradictions and dilemmas inherent in the university invention ownership model.

The TLO

Even the largest TLO is a small part of a major research university; nearly all of which have total budgets exceeding \$1 billion. 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 2006, approximately 20 percent of the TLOs had more than fifteen TLO professionals (AUTM 2006). In such large TLOs, direct and indirect expenditures are likely to be approximately \$2 million.¹⁴ 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. There are outliers such as NYU, which received \$197 million in 2006, and Columbia University, which did not report its income to AUTM (AUTM 2006).

For administrators TLO income is attractive because the funds, though meant to be used for further research, are, in fact, largely unencumbered, giving administrators wide discretion on how to spend them. Often the support monies for TLO personnel can originate from public funds, either federal or state. This asymmetry offers a powerful incentive – restricted funds can be spent to operate the TLO, while earnings are far less restricted. The strength of this incentive is difficult to measure, but it may be considerable as more flexible 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 et al. (2004) consider the TLO as the inventor's agent, an excellent idea, but in the current situation an impossible formulation because the inventor has no contractual authority over the TLO. A somewhat different

¹⁴ 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. If the TLO is filing large numbers of patents or

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 is an agent of the university, although for success it depends upon the inventor's knowledge and cooperation. Oddly, the professor is also an agent of the university. But in this particular relationship, the TLO has only a tenuous and highly mediated control of the inventor. For these reasons, characterizing the inventor-TLO relationship as one in which the TLO is an agent of the inventor is fallacious.

A more realistic formulation of the TLO-inventor relationship is vital.¹⁵ Consider a world of zero transactions costs in which there is perfect information for all parties regarding the value of an invention, no time constraints, infinite bargaining time on the part of the inventor and in the marketplace, costless transactions between the university, inventor and the licensing firm, or just between the university and inventor/entrepreneur in the case of a startup. In such a case one would have a socially optimal outcome. Perfect information allows all parties to see the same future benefit from an invention, and bargaining among the parties results in costless sharing of this benefit regardless of invention ownership. In such a world the assignment of property rights would only affect 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.

litigation, then costs rapidly spiral.

¹⁵ On the value of appreciative theorizing, see Nelson (1995).

A basic rule for economic efficiency is that entitlements should be assigned to the party most likely to make optimal market judgments. Calabresi and Melamed (1972) analyzed entitlement protection through property and liability rules in a world characterized by transactions costs and imperfect information. They concluded that 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 insights can be applied to intellectual property rights in university inventions. That is, a parallel can be drawn between the concept of least cost avoider in the case of externalities, and the least cost (or most effective) innovator in the case of technology transfer.

In their theoretical work, Jensen and Thursby (2001) model a university invention 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 disclosure and effort on the part of inventor to transfer the invention – despite the fact that the inventor is a university employee. To elicit this cooperation, the licensee is charged an upfront license fee and a revenue-based payment, both of which are shared with the inventor (and often the inventor's college and/or department). 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 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. Lowe presents a base model in which the university inventor owns the invention, and he 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. In Lowe's model, the inventor has the option of forming a startup instead of licensing the invention.

When the university TLO is introduced, as the intermediary between the inventor and the potential licensees, the outcomes change. The TLO must expend 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 of the inventor founding a startup, it 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 – which are contingent upon successful commercialization (of course, the university could also demand equity). This 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.

One justification for university ownership is that it administers and manages the intellectual property of the university inventor, i.e., it performs a service. This justification, though, most reasonably applies in those cases in which the invention is licensed. If the inventor is intent upon establishing a 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 terms of institutional power and licensing experience. 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.

An affirmative case for university ownership has been advanced by Thomas Hellman (2007). His model assumes that the TLO, acting on behalf of the university owning the patent, has knowledge superior to that of the inventor 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 the current situation is optimal. There is, of course, a problem in this formulation because the inventor is not delegating, the TLO already has ownership. If the TLO is not more effective in search than the inventor, then it is preferable that the inventor has the rights (Hellman 2007: 28).

Does the TLO, as Hellman (2007) argues, have search capabilities superior to the inventor? This scenario is dubious as 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 ideas about the invention and its possible applications. Thursby and Thursby (2003) confirm this in 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.”

Market knowledge is often treated as costless, but as Cohen and Levinthal (1990) and many others have shown, valuing and using knowledge depends upon the

development of costly absorptive capacity. In a business setting, this capacity is usually not general but rather sector specific. This observation applies to university technology commercialization, also.

Consider the Ohio State University Technology Licensing and Commercialization office, which employed 16 professionals (Ohio State University 2007) and earned \$957,000 in fiscal year 2007 (Gibson 2007). The 2006 Ohio State research budget was \$652,329,000 (NSF 2007). The OSU Technology Licensing and Commercialization Website lists inventions available for licensing.¹⁶ These were only the disclosures that the TLO believed were sufficiently promising to patent and pursue. The Website is divided into 19 separate technology categories with 308 total listings, and within each there are multiple inventions. Each category contains an eclectic set of inventions. As an example, three inventions were in the agricultural and food processing category – a way to make “heart healthy soybean bread,” a technology to create new fruit shapes, and an assay to detect a livestock disease. The technology transfer personnel cannot be aware of all of the nuances of a particular technology and its relevant business opportunities – not because of a lack of competence, but because the inventions stem from radically different practice communities.

When we allow that transactions are costly, property right assignment matters and errors 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 upon the experience and capabilities of both with respect to the particular invention.

Unfortunately, these cannot be known a priori. If transactions costs and time loss between

¹⁶ 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.

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 are important, and they clearly are in the case of most electronics inventions or, if venture capital is required as VCs normally work on a 9-month staging cycle, then a retarded assignment (or TLO procrastination) can result in economic loss.¹⁷ In cases in which the university inventor wants to bootstrap the technology by using non-dilutive small business innovation research grants, a TLO desiring licensing fees and royalties would be a retardant.

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 wishing to commercialize a technology is most likely to understand the invention best, to have some informed belief regarding its potential, and to have the greatest motivation.

An asymmetry in transaction costs between the university inventor and the TLO is likely. Suppose a TLO represents the most effective vehicle for exploitation, but the ownership resides with the inventor. How will these parties react? Both will 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 as it becomes either the owner or the inventor's agent.

¹⁷ This may not be a problem at all TLOs. Katharine Ku (2008) states that at Stanford they aim to provide the inventor with an answer in less than one month.

Now suppose that the inventor would be most effective in commercializing the innovation, but the entitlement has been granted to the TLO. There are likely to be costs to the inventor in securing the rights to the invention. Alternatively, the TLO could contract for the services of the inventor to commercialize the invention. Presumably, this consequence occurs in the current model by the inventor being motivated through receiving a share of the invention's revenues. This complicated set of conditions would be avoided by consistently awarding the rights to the inventor who would then decide on the commercialization route.

The TLO as an organizational form has contradictions and hard-to-fulfill mandates. Regardless of whether they are well-managed, TLOs occupy a conflicted position in any technology commercialization process. Based upon observational research, Owen-Smith and Powell (2001) found that their well-managed TLO at an entrepreneurial private university operated smoothly with considerable success. The other TLO at a large public university experienced significant operational difficulties. Obviously, a badly managed TLO can impede technology transfer. To illustrate, in their research at elite universities with presumably well-managed TLOs Colyvas et al. (2002) found a case in which the TLO's desire to protect the university interest in an invention complicated the transfer process. In our discussions with campus inventors, we have heard many cases, anecdotes, and rumors about other cases in which the need of the TLO to protect its proprietary position complicated or retarded commercialization.

As a bureaucratic entity, the TLO may also be the victim of university political decisions as decisions to patent may not be made purely on merit. To illustrate, if an 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 results in the loss of significant overhead income.¹⁸ In an effort to retain faculty members who attract large grants, the TLO's superiors may demand favorable but inefficient decisions.

Recent modeling exercises in industrial organization economics, using a large number of simplifying assumptions, have argued that TLOs provide important benefits to inventors and potential licensees. For example, Heidrun C. Hoppe and Emre Ozdenoren (2005) developed an economic model arguing that the TLO offers advantages to the inventor because the TLO can pool inventions from several laboratories thereby providing better service. This variant on the economies of scope argument is problematic if the technologies arise from a wide variety of communities of practice (for further discussion of this likelihood, see below). The difficulty when this model is applied to the real world is that the TLO owns the inventions regardless of its ability and even desire to provide service. Conversely, if the TLO is competent and can use its economies of scope, then in an inventor-ownership model, the inventors would recognize and value this advantage and voluntarily contract with TLOs.¹⁹ Given, as Powell et al. (1996) show, that inventors are embedded in networks of other inventors, reputation effects would result in the selection of the most effective TLOs and demise of the ineffective ones.

¹⁸ The total overhead earned by a research university is significant. For the sake of argument, if one assumes that 80 percent of Ohio State University's research budget for 2006 of \$652,329,000 is billed at an overhead rate of 50 percent, then the total annual overhead income is in excess of \$172 million. Even at universities with large TLO income, such as Stanford, which earns approximately \$50 million per year, such overhead is important. In 2006 Stanford would have received by the same calculation \$179 million in overhead.

¹⁹ Interestingly enough, this particular stream of theorizing has a historical precedent in the United States. During the 19th Century technology/patent brokers emerged to assist inventors in monetizing their inventions (Lamoreaux and Sokoloff 2001).

In another modeling exercise, Ines Macho-Stadler et al. (2007: 483) show that a TLO could develop a positive reputation among invention buyers through vetting and “shelving” lower-quality disclosures, thereby raising potential buyer’s belief regarding the expected quality and presumable price. They hypothesize that this model would result in selling fewer but more valuable inventions. In this case, they assume that the TLO is more capable of judging an invention’s value than the potential licensee or the inventor – a dubious assumption. Since the TLO, not being omniscient, would concentrate its efforts on only those inventions it considered most valuable, it could easily overlook potentially valuable inventions. In any case, all TLOs have an incentive to develop good reputations. Invention quality is not the only issue affecting potential licensees. These theoretical findings shed no light on whether the inventor or the university should retain ownership rights. Presumably, inventor ownership would improve TLO operation by replacing bureaucratic control with market forces.

TLOs and their personnel are, for good reason, often measured in terms of revenue. For these TLOs, the emphasis naturally shifts to extraction of the greatest amount of income. Because nearly every university is based on annual budgets,²⁰ the dominant strategy would be to favor up-front payments from deep-pocketed large firms and to pursue aggressively only those inventions that the technology licensing officers believed had the greatest potential pay-off (Lemley 2007).²¹ Concentrating on only inventions with clear pay-offs could inadvertently limit university research spin-offs. In a study of the commercialization of university-derived inventions in electron microscopy

²⁰ TLOs having 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.

²¹ Predicting in advance the pay-off from a new invention is 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.”

by 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.”

There are many perverse incentives. Larger, more successful TLOs can have a longer-term perspective and to maximize return may use patent troll-like strategies such as pursuing “submarine” patents.²² An excellent example is 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; Colaianni and Cook-Deegan 2008).²³ This strategy suggests that the primary goal of Columbia’s TLO is not to transfer technology but to maximize revenue. Efforts to extend the patents, by whatever means necessary, are entirely logical when one considers that Columbia faced losing annual revenues exceeding \$50 million. With such revenues, contributions to knowledge transfer and social welfare are deemed not as important, though they may be by-products.

In the case in which the inventor wants to form a firm to exploit the invention, there is a high probability that the inventor’s interests will diverge from the interests of the revenue-maximizing TLO and will converge with that of a prospective licensee, the professor’s firm. In fact, Markman et al. (2005) found that the most “attractive”

²² A “submarine” patent is an informal term for a patent first published and granted long after the original application was filed. In such cases one set of individuals may invest significant sums in developing a body of knowledge without being aware that there exists a firm that already has a patent on this 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 are now hostage to the patent owner.

²³ The virulence of this drive for more income was on display when Columbia University lobbied a U.S. senator to add an amendment to a completely unrelated bill in an effort to extend the Axel patents (*Harvard Journal of Law and Technology* 2004: 596).

combinations of technology stage and licensing strategy for new venture creation, i.e., early stage technology, combined with licensing for equity, were the least likely to be favored by the university. This was because many university TLOs are risk-averse bureaucracies focused on short-term revenue maximization. Oddly enough, knowing this, recently there have been recommendations that TLO managers be provided with incentive pay (Link et al. 2007), which can only lead to increased short-termism with high up-front licensing fees discouraging entrepreneurship and encouraging greater aggressiveness on the part of the TLO personnel in encouraging/demanding disclosure.²⁴

Because the function of a TLO is not to “transfer” technologies, but to monetize inventions, under normal circumstances it negotiates a sale of rights to a commercial entity. The commercial entity, because it operates in specific business areas, almost invariably has a better understanding of the value of the invention than does the TLO. In addition, the commercial entity has the possibility of approaching the professor directly for a consulting relationship to organize a “gray” technology transfer (Link et al. 2007). For this reason, the licensing party almost always has superior information and alternatives.

The likely response of any owner in a situation in which other parties to the negotiation have superior information, and possibly alternative channels for commercialization, is to hesitate until more information is available. If the TLO is risk-averse, then the instinct to hesitate will be even more compelling. Since the TLO has ownership, procrastination incurs no direct cost, though there may be enormous (but never known) opportunity costs. Should the TLO act hastily, the outcome is likely to be

²⁴ It would almost certainly lead to even less willingness on the part of TLO managers to release any technology pro publico bono, as eventually was the case with university decisions to pressure licensees to

suboptimal for the university and the inventor. This disadvantage is further complicated in cases in which the inventors believe themselves to have superior information; in such cases, they may lose faith in the TLO and refuse to cooperate.

The relationship between the inventor and the TLO is usually considered as a single event. However, as the TLO operates, it acquires a reputation affecting future relationships (Owen-Smith and Powell 2001; Macho-Stadler et al. 2007).²⁵ A positive reputation for managerial excellence encourages trust on the part of both the inventor and the licensees. When unaddressed difficulties are experienced by either the inventors or the licensees, a negative reputation for the TLO can ensue, decreasing trust. Since inventor communities are characterized by high levels of communication (Brown and Duguid 2001; Bercovitz and Feldman 2008), these subjective experiences are certain to be communicated throughout the networks (on networks in biotechnology, see Powell et al. 1996; 2005).

The negative experience suffered by the inventor or entrepreneur can be enormously costly to the university. Conversely, the positive experience of James Clark – a professor at Stanford University until 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 he was 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

provide favorable terms to poorer nations. For debate about this issue, see Butler (2007), Nelsen (2003).

²⁵ For an exhaustive discussion of the economics of reputation, see Cabral (2005).

so frustrating that they ultimately rewrote the browser code entirely. By 1999, the University of Illinois had successfully collected \$7 million from the Mosaic copyrights, but the ill feelings of the Netscape founders almost certainly cost the university a far greater amount in lost donations (Kesan and Shah 2004: ff454; Reid 1997: 37).

Frustrating entrepreneurs through difficult financial and contractual demands is likely to be so costly in terms of future donations that it far outweighs the gains from licensing. As with any organizational unit, TLOs are boundedly rational. They may pursue their office's interest to the detriment of the university's interests.

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 can be a risk-adverse bureaucracy frustrating technology transfer and fostering the cumulative development of a negative reputation. Some TLOs have reputations for being difficult or incompetent, and thus they are either shunned or approached by potential licensees adversarially (Greenbaum and Scott 2008; Owen-Smith and Powell 2001; Silverman 2007). TLOs may develop adversarial relationships with the faculty, discouraging further disclosures, discouraging contribution to patent maintenance and extension, and discouraging participation in the transfer process so necessary for the licensee to monetize the invention. A reputation for adversarialism encourages the inventor to circumvent university regulation by transferring inventions to off-campus entities outside the official disclosure system. The belief that the mandatory TLO ownership model is necessary for technology transfer is not based in fact.

The Inventor

Many researchers choose a university career because of its relatively unstructured, unsupervised, and collegial environment. 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. To illustrate, it is nearly impossible to terminate the employment of tenured faculty. Further, faculty members engage in unique specializations whose substantive content may not be understood even by their first-line “supervisor,” the department chairperson, who is a colleague. To evaluate the performance of faculty members, administrators rely upon departmental colleagues and the external invisible college of peers to pass upon research quality, funding requests, and personnel decisions.

The sources of research support are predominantly extramural, for specified projects, and subject to little control or strategic direction by university administrators. A faculty member’s work process is largely immune to direct control and supervision by the administration. Further, certain valuable faculty outputs, such as textbooks, belong to the faculty and not to the university. In contrast, the source of the corporate researchers’ funds is, as a rule, internal; managers have direct control over the funds; and employment can be terminated at will. Modeling professors with the same constraints, motivations, and structural position as employees of a for-profit firm or, for that matter a civil service bureaucracy, is flawed. University inventors have significant independence, and they are subject to little effective oversight – a recipe for a complicated relationship and a lack of corporate-style accountability.

Though university researchers are required to disclose and assign their inventions to the university, this requirement is not easily monitored or enforced (Siegel et al. 2003; Markman et al. 2008). The literature suggests that the best way to encourage disclosure on the part of university employees is to increase their share of the invention's income. Lower royalty rates encourage firm formation (Di Gregorio and Shane 2003), implying that researchers are sensitive to the opportunity costs of forming their own startup. This incentive assumes that university inventors are necessarily motivated to receive as high a royalty as possible.²⁶ 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 arrangement creates contradictory motives for the inventor.

When an inventor participates in the TLO process, difficulties may arise if the inventor believes, rightly or wrongly, that the TLO is mismanaging the process or generating insufficient income. Should inventors believe that the TLO is investing insufficient resources in their invention or that the TLO is incompetent, compliance with the university's rules can decrease and relationships can become antagonistic. In the case of prior disclosures, the inventor has little recourse. However, for new inventions, alternatives to disclosure exist. In contrast to a firm in which there presumably is much greater monitoring of researchers, the university is organizationally unable to supervise strictly without violating its core values.

Many professors have established firms or developed intimate relationships (very often including tangible economic incentives) with firms undertaking research and development (R&D) in fields closely allied with their university research. This

²⁶ The share of inventor's royalties differs by university. 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

phenomenon suggests that there may be a “gray market” for inventions (Markman et al. 2006; Mody 2006: 79). The gray market is difficult to measure but is surely substantial. From a sample of National Institutes of Health, National Cancer Institute grantees, David Audretsch et al. (2006) found that over 20 percent of the professors had established firms in their field of expertise without university licenses. In a study using patents, Markman et al. (2008: 33) found that over 42 percent of the professors who did patent, for one or more of their inventions they had bypassed the university TLO. Paralleling Rappert et al.’s (1999) findings, Markman et al. (2008) found that professors not disclosing patentable inventions were more likely to establish a firm. From a large population of university faculty patents, Thursby et al. (2008) find that 26 percent of all faculty patents were assigned directly to firms, however they note that these patents were less basic than those assigned to universities. From this they conclude that, at least some of the firm-assigned faculty patents may be the fruits of consulting work and thus not all of these are necessarily part of the gray market. Though not all the technology transfer is undertaken to avoid university assertion of ownership, these results suggest that technology can be transferred without the intermediary of a TLO, and in, at least some cases, this transfer is in lieu of university ownership.

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 often not difficult 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. In computer science and other

from the gross income.

engineering disciplines, transferring inventions is usually easy, as the location of the inventive activity is fungible, and there is less written evidence such as laboratory notebooks to establish the genesis of invention. It would be uncomfortable for the TLO to be placed in the position of investigating university faculty members – although it should be recognized that universities do investigate faculty and staff for a variety of reasons. Worse, if violations were found, then potentially embarrassing disciplinary action would have to be taken. Motivated inventors have ample opportunity and means for circumventing the TLO.

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 possible to found a firm to exploit the now “open source” invention. This strategy is likely to be simplest in engineering and computer science, but it is feasible 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. In addition, raising venture capital to appropriate the open source knowledge may be more difficult.

Inventors might also disclose the invention, and then provide no further cooperation with the TLO. In such cases the TLO has little advantage. Non-cooperation ensures that licensing will be difficult, and it could compel the TLO to provide a low-cost license to the inventor. The costs of non-cooperation are low.

From an economic perspective, the inventor’s position is curious. First, university employees are legally obligated to disclose inventions. And yet, enforcement is difficult.

Link et al. recognize this difficulty (2007), and they conclude 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 university incentive structure to suit the needs of the flawed current TLO model. In other words, research, teaching, and contributions to the general societal knowledge pool would vie with patent-generation and firm-formation as university goals. They would raise a minor appendage of the university and an insignificant source of funds to a central goal of the university – and this without any evidence that such a radical change in policy would contribute either socially desirable effects or generate greater economic activity. This structure is a recipe for transforming first-tier research universities into a hybrid of corporate contractor and small firm incubator.

Alternative Invention Ownership Models

Given the contradictions, misaligned incentives, and inefficiencies inherent in the extant patent ownership model, we propose two other models be considered. The first model is based on the premise that inventor ownership will result in greater and faster technology commercialization. What the model cannot answer is the normative argument of whether the university should be rewarded for being the institution within which the invention was gestated. 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 or variants upon it have been proposed by others (Eisenberg 1996; Nelson 2003; Rai 2005; Rhoten and Powell 2007). In this model, all university inventions would be treated as open source and would be made available to all users. This approach would eliminate licensing. A less drastic form of this model is to require mandatory non-exclusive licensing. In the full open source model, the university would be removed from the technology transfer process. It would return to its role as a platform for research and instruction. In the non-exclusive licensing model, the university TLO selects technologies for patenting, establishes a licensing plan, and enforces licensing terms.

Inventor Ownership

The inventor ownership model vests the rights in the inventor who, as we already have shown, is most likely to have the best information. This model already exists as a default practiced in cases in which universities decline to exploit the invention and the inventor petitions the federal sponsor for the rights (Chew 1992).²⁷ 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. In an inventor-ownership model, they would be the principals, and they could secure an agent. The TLO would benefit in that it could specialize. Further, it would be relieved of the pressure to manage inventions that have little prospect of success, but for which it has responsibility. Altering ownership rights would force TLOs

²⁷ It is possible for the inventor to petition the funding agency for the rights to an invention, but this is time-consuming and costly.

to operate as service organizations and to shift the relationship from one structured to serve the TLO to one structured to serve the inventor-owner.

TLOs would either become self-supporting or discontinue operation. The inventor ownership model need not lead to the demise of the university TLOs, as their location on campus provides a strong advantage. The many faculty inventors not wishing to expend time and effort on commercializing their inventions, but also hoping that the invention would be successfully commercialized, are likely to voluntarily turn to their local TLO. This prospect is not fanciful. In 1969 when Niels Reimers established the Stanford TLO, he was faced with having to convince inventors of the utility of the TLO.²⁸ These starting conditions may explain why the Stanford TLO retains a strong “service” orientation (Ku 2008; Owen-Smith 2005).

There are benefits beyond efficiency. In fields such as computer science software inventors often wish to place their programs into the public domain, but the TLOs demand that these programs be patented and licensed. In the inventor ownership model, the inventor would make the decision unfettered by institutional constraints. An inventor ownership model would relieve researchers of the affirmative obligation to disclose any patent inventions made in their laboratory, and to assist the university in prosecuting patents. Researchers could choose to dedicate their inventions to the public without violating their employment contract. In many cases, the open source arrangement would serve the public good by rapidly diffusing the technology and saving valuable researcher time.

²⁸ See Nelson (2005) concerning Reimers first successful patent and licensing of software for musical synthesizers.

Beyond the efficiencies, the institution of an inventor-owned patent model would remove the temptation to judge faculty members based on the financial return they can provide the university. 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. This disparity could be addressed through employment contracts providing that the university receive a tithe from its inventors of, for illustration purposes, five percent of the equity or licensing proceeds of any invention university researchers make in their fields of expertise. This pre-arrangement would shrink the burgeoning gray market vexing the current university ownership model. The tithe should be sufficiently small so as not to discourage inventor commercialization. Put simply, addressing normative issues is not precluded by the movement to an inventor ownership model.

Inventor ownership is not a panacea, but it would not worsen existing problems. In cases in which an invention has multiple inventors, regardless of the ownership model, priority and ownership must be determined. Whether a TLO can do this more effectively than the parties can or, if necessary, the civil courts, is dubious. If the TLO decides unfavorably to certain claimants, the decision is likely to be challenged in the courts. If inventors are at separate institutions, the ownership determination process will be more complicated since not only the inventors, but also their respective TLOs, are involved. Given the greater number parties and interests involved, arriving at a settlement is likely to be more difficult.

The university administration's role in an inventor ownership model would change in that it would not be responsible for technology licensing. It would return to its

earlier and more important charge—ensuring that faculty members discharge their institutional duties. Inventor ownership might increase the exploitation of students, but there is no evident reason that this exploitation would be more prevalent than it is today – and the administration would not have the appearance of conflicts of interest. 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 problem of gray markets. Inventor ownership should not generate serious new problems, although it would solve some of the current difficulties and inefficiencies.

Another valid concern regarding the inventor ownership model is whether this would be more likely to stifle the flow of information and materials. There is no definitive answer to this concern, but our suspicion is that faculty inventors may be more sensitive to pressure from their peers than TLOs may be. Nonetheless, if university researchers have their own firm staffed with professional managers, their willingness to provide information and materials is likely to be reduced – but this would also be true if the professor has a firm that licenses technology from the university.

No model can relieve the tensions that, almost by definition, will exist at the interfaces between the university and business. The inventor ownership model would remove research commercialization from the control and mission of the university administration and would decentralize it to the inventors. We have shown the efficiency reasons for such a model and have argued that in terms of the speed and effectiveness of technology transfer the inventor ownership model would result in superior outcomes. In terms of information and material flow and good governance within the university, there

is little reason for inventor ownership to be socially inferior. In the next subsection, we briefly explore cases in which the inventor ownership model has existed.

Experiences with the Inventor Ownership Model

The inventor ownership model is currently uncommon in the United States, so there are no direct domestic comparisons.²⁹ Two universities, Stanford and Wisconsin, had policies in the past that allowed campus inventors to appropriate inventions that were made with “gift” accounts or foundation grants and thus not restricted by the funding agent. Even more pertinent, the University of Cambridge is a useful comparison because up until a new mandatory university ownership scheme was implemented beginning in 2001, researchers owned their inventions. The final comparative case is Europe, which has a variety of different models and where technology transfer, until recently, almost entirely occurred outside official university channels.

Stanford has a long history of entrepreneurial technology transfer (Lowen 1997). In an archival study of the evolution of the Stanford Office of Technology Licensing procedures, Jeanette Colyvas (2007: 468) shows in the biomedical field that initially there were four quite different models for organizing the relationship between university laboratories and firms. Eventually, these models merged into a single institutionalized model that combined elements of the early models.³⁰ She concludes that “money and entrepreneurship were outcomes rather than an input” (Colyvas 2007: 474). In the biomedical field, “the subsequent outpouring of royalties, many years after the original

²⁹ The Research Corporation and WARF come directly from the inventor ownership model, created by faculty inventors who were concerned about the negative effects of direct university ownership (Mowery et al. 2004).

research (and early debates about how to organize the intersection of commerce and academe), caused the remaking of existing arrangements, resulting in the recasting of technology transfer practices.”³¹ There is no doubt that Stanford University faculty, students, and staff were generating commercializable inventions, though as Colyvas and Powell (2007) show, at Stanford, commercialization activity in biology grew most rapidly in the 1990s.³²

In digital technologies the Stanford TLO was less involved, yet in the 1980s it was in this field that most visible technology transfer occurred. For example, in 1982 Sun Microsystems (Sun was an acronym for Stanford University Network), a firm commercializing networked workstations resulted from an entrepreneurial collaboration between three Stanford graduate students and a UC Berkeley graduate student. In 1984 Cisco Systems was formed by two Stanford network administrators who built routers to link the then separate Stanford local area networks. Similarly, in 1982, Silicon Graphics commercialized a software program, the Geometry Engine, that Professor James Clark and graduate students had developed at Stanford. Each of these university-developed technologies was successfully commercialized without the use of a technology licensing office. From the Stanford case, there was technology transfer without a TLO and little evidence that technology transfer increased since the 1994 decision to require that all inventions developed at Stanford be disclosed to the TLO. In the case of Stanford there is no evidence that technology transfer has been frustrated by the TLO, but then the Stanford TLO has the reputation for being among the best (Colyvas 2007).

³⁰ The first important income-generator for the Stanford TLO was a patent filed in 1970 for frequency modulation in electronic music instruments.

³¹ In terms of entrepreneurship, the blockbuster 1980 Genentech initial public stock offering demonstrated the potential value of research results in the new genetic engineering technologies (Kenney 1986).

The University of Wisconsin, Madison, shares some similarities with Stanford, as university faculty to this day own any inventions that are not encumbered by sponsor restrictions. Of course, because of the B-D Act, all federally funded inventions must be disclosed to the university, which assigns them to WARF. In contrast to Stanford, there is no evidence of large and significant spin-offs exploiting unlicensed UWM technology. The technology licensing model at UWM was established in 1925 through the voluntary decision of the faculty inventor to set up an off-campus entity, WARF, to administer what would become a lucrative patent for using ultraviolet irradiation to increase the Vitamin D content in food. Later, WARF received and administered the rights to the blood thinner dicoumarin in 1947 and the rodenticide Warfarin in 1948. These inventions were licensed to large firms and almost certainly would have been commercialized either with or without patents.

UWM has had large numbers of spin-offs during the last four decades and WARF has successfully licensed many technologies to them. In a study we undertook to identify all direct UWM spin-offs, as defined by at least one founder directly affiliated with UWM before formation of the new firm, we found that UWM had from 1957-2006 spun off 112 firms.³³ Unfortunately, we have no way of identifying the licensing status of these firms. Probably the most important university-related firm in Madison, Promega, was established by a former UWM graduate student to commercialize reagents and other inputs for biology laboratories. Though it later would license university technologies, it was established without going through the university. The preponderance of these spin-offs came after 1980, and spin-off formation accelerated in the 1990s, which roughly

³² Despite the critical importance of Stanford's TLO as a model, the most important early Bay Area biotechnology firms were spin-offs of the University of California, San Francisco (Jong 2006: 252).

parallels the findings of Colyvas concerning Stanford-licensed biomedical spin-offs.

UWM's most important licensing successes came prior to B-D and appear to have been voluntary assignments.

Since rules concerning ownership of patents arising from federally funded research are applied uniformly across the country, it is not possible to compare contemporaneously different inventor ownership models in the United States. It is noteworthy, though, that Stanford was the source of many valuable university startups after B-D, yet before the university's 1994 policy mandating disclosure of inventions to the TLO.

The purest case of a university practicing inventor ownership until recently is the University of Cambridge, which according to many global rankings is the premier science and technology university located outside the United States. Though there are no international comparisons, it is also quite possible that it has been the most fertile university in terms of technology-based entrepreneurship outside the United States (Garnsey and Heffernan 2005; Druilhe and Garnsey 2004; Myint et al. 2005; *The Cambridge Phenomenon* 1985).³⁴ With reference to inventor ownership, Elizabeth Garnsey and Paul Heffernan (2005: 1129) describe the situation at Cambridge:

Central administration was minimal until after 2000 and did not have the means or inclination to manage technology. . . . From 1986, British universities had rights to intellectual property in work funded by the Research Councils. The

³³ This data is available from the authors.

³⁴ There is no existing database to compare entrepreneurship across universities. A possible contender to this is China where the Chinese Academy of Sciences and elite universities have been the source of large numbers of spin-off businesses, both in technology and other fields (Chen and Kenney 2007; Lu 2000).

University of Cambridge was unusual in vesting this entitlement to inventors on its staff. In laissez-faire mode, no active support for technology transfer was provided in the early period.

This policy was changed only in 2001, as the University of Cambridge conformed to new UK government rules implementing a B-D-like university ownership model.

Cambridge has a history of successfully spinning out university technology-based firms. For example, Celine Druilhe and Elizabeth Garnsey (2004), using a rigorous methodology of counting only direct founder spin-offs, found 109 direct university spinouts. The Department of Engineering alone from 1970 through 2004 spun off 34 firms. Acorn Computer, which spun out of the University Computer Laboratory in 1979, gave rise to 32 second-generation firms. Finally, there were some biotechnology spin-offs from the University (Garnsey and Heffernan 2005). These past successes created an environment conducive to further entrepreneurship.

In 2001, a B-D-like model was implemented at Cambridge whereby the University took ownership of all faculty inventions. It is perhaps too early to be certain of the ultimate effect of this transition. In a study of biotechnology spinouts, Shiri Breznitz (2008) found that from 2001 when the new model was implemented through 2004, the number of biotechnology spin-offs decreased, even while the UK and global population of biotechnology firms increased. Breznitz's results indicate that implementing B-D might be retarding technology diffusion, at least through individual entrepreneurship, the mechanism that made Cambridge the most successful entrepreneurial region in Europe. The Cambridge case provides the most clear-cut before-and-after case study in the world

– and thus far the evidence strongly suggests that a B-D model was not necessary and may actually be impeding technology transfer.

In Japan and many European nations, inventor ownership has been the norm and universities did not have TLOs. In addition, these nations had little visible university entrepreneurship. National and regional governments, often at the urging of academics from the United States, came to believe that the lack of a B-D mechanism explained this lack of commercialization through startups. Ignored was the fact that they had little technology-based entrepreneurship of any kind. For this reason, and when compared to U.S. universities such as Stanford and MIT, it appeared as though there was a dearth of technology transfer.

The conclusion that there was little or no technology transfer was always dubious. For example, Kenney and Florida (1994) showed that technology transfer by Japanese public university professors was to existing businesses and came through “under-the-table” consulting, as all compensated professorial consulting was forbidden at the time. In addition, there was an established system of dispatching corporate researchers to work in university laboratories where they learned the technologies. It is difficult to judge how effective the system was, but there was significant technology transfer. Rene Carraz (2008) studied patenting practices at Tohoku University, Sendai City, one of the elite research universities in Japan, before and after Japan implemented a B-D-like law. Only two years after this law was implemented, professorial patenting with firms fell by more than 50 percent, while direct university patenting increased dramatically, even as total university-based patenting was essentially unchanged. This finding suggests that inserting a TLO intermediary into the technology transfer process changed the channels of

patenting, but the intermediary did not change the quantity of patenting. It is unlikely that inserting a TLO intermediary into this process has made it more efficient.

The Continental European case is complicated because each nation had its own policies and practices. In a recent article, Geuna and Nesta (2006) summarize the available evidence finding that in the case of Europe “the rapid rise of academic patenting in the closing quarter of the 20th century was driven more by the growing technological opportunities in the bio-medical sciences (and maybe also in ICT) and the feasibility of pursuing those opportunities in university laboratories, than by policy changes affecting the universities’ rights to own patents arising from publicly funded research.” However, most patents were not owned by the university. For example, Crespi et al. (2007) in a study of 9,000 European Patent Office inventors found that 82 percent of the patents by university personnel were not university-owned. Similar results are available for other Continental European nations (Azagra Caro and Llerena 2003; Balconi et al. 2004; Meyer 2003; Saragossi and van Pottelsberghe de la Potterie 2003). These studies demonstrate that inventor ownership systems can have significant levels of transfer even without official university involvement or visible entrepreneurship. This transfer occurs even in nations without the powerful entrepreneurial support networks existing in the most successful U.S. regions.³⁵

The evidence from Stanford and UWM provides only anecdotal support to our argument for a new ownership regime. Stanford had some important spin-offs that did not use the TLO. At UWM, as at Stanford, there undoubtedly would have been many spin-offs regardless of the ownership model. The University of Cambridge is the clearest case in showing that an inventor ownership model can be successful in transferring technology

and encouraging entrepreneurship. The European and Japanese experiences with inventor ownership demonstrate that TLOs are not necessary for technology transfer, even though in most of Europe the complementary assets for entrepreneurship are missing.

Unfortunately, there are few published studies regarding the changes in technology transfer given the ownership model changes occurring as European nations adopt B-D-like policies. Technology transfer does occur in environments without university ownership, and the University of Cambridge shows that this transfer can be substantial.

*Weaker Ownership Rights Models*³⁶

Another model that has received interest is a mandate that all inventions generated through federal support are de jure placed in the public domain or, less radically, only licensed on a non-exclusive basis (Eisenberg 1996; Nelson 2003; Rai 2005). Since non-exclusive licensing is a “tax,” and shifts the invention rents from one actor to another, an open source model would go further by socializing the value of the inventions (Rhoten and Powell 2007). For basic process innovations, even in biology, an “open” strategy is as effective as, 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 model would be for proprietary pharmaceutical compounds that might not be developed absent exclusive patent protection (Levin et al.

³⁵ On entrepreneurial support networks, see Kenney and Patton (2005).

³⁶ For an extended discussion of this, see Rhoten and Powell (2007).

1987; Mansfield et al. 1981).³⁷ Even here there have been alternatives. For example, there were no patents on the anti-cancer drug Taxol, and yet it was successfully commercialized (U.S. General Accounting Office 2003).³⁸ The case of penicillin suggests that the Taxol case might not be as exceptional as many believe (Kingston 2001; Neushul 1993).

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.³⁹ Possibly, a small firm could be established to commercialize university findings, and, as it operates, create commercially valuable proprietary knowledge. Alternatively, once the knowledge is in the commons, entrepreneurs may capitalize on the knowledge and form yet other firms. This dynamic operated in the open source software field as cost of entry is very low. Whether the IT model would work equally well in pharmaceuticals is uncertain.

For the university, open source would ameliorate current concerns about commercialization influencing its mission or unduly influencing faculty. In many cases, it 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 model, considering an open source model provides an alternative reference point for considering other ownership models. Thus, using an open source model may lead to

³⁷ Lori Pressman et al. (2006) show that the number of truly exclusive patents licensed by universities is quite small, and exactly as expected are for therapeutic molecules.

³⁸ Florida State University received a patent and over \$200 million in licensing revenues for patents it had on a technique for synthesizing Taxol.

³⁹ On complementary assets, see Teece (1986). In the case of pharmaceutical and biotechnology firms, see Rothaermel (2001).

better solutions compared with using the “perfect world” assumptions underlying most economic models.

Conclusion

Organizational arrangements are outcomes of social and political choices, but most arrangements soon develop a facticity and aura of normalness that discourages critical evaluation. Today, the university ownership model is framed as the natural method for organizing the interface between university inventions and inventors and the economic realm. 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 in technology transfer have until recently been dealt with only in passing (for exceptions, see Litan et al. 2007; Mowery et al. 2004; Powell et al. 2007). It is so “natural” that, with a few exceptions, academic research on university spin-offs uses the data provided by TLOs, which almost always omits entrepreneurial firms not using the TLO.

The current organizational location and operational imperatives of the typical TLO trap it between its so-called goal of assisting technology transfer, and the primary metric upon which it is measured, revenue-generation.

Today, the more experienced and well-managed TLOs are usually the ones with the greatest revenue streams, and therefore they have the ability to sustain a longer, less narrowly focused perspective and, in some cases, a commitment serving the inventor. Yet, some larger TLOs have become—like the University of Wisconsin, Madison, Columbia, and others—so focused on revenue, it is possible to argue that the TLO

income has become of greater importance to the university than disseminating knowledge and operating in the interest of society. Then there are many other TLOs that are staffed by less skilled and less experienced personnel who by virtue of the structural location are risk-averse and bureaucratic. Research and anecdotal discussions suggest that some unknown number of inventors are responding by giving only grudging cooperation and actively seeking to circumvent the TLO. Despite these furtive responses, in the university ownership model, inventors are at the mercy of their university's TLO regardless of its competence.

We demonstrated that for many important university inventions, patents and TLOs were unnecessary for their diffusion and adoption. We provided suggestive anecdotal evidence that TLOs in the university ownership model may retard the diffusion of technology. This impediment arises because very often in the university ownership model, the TLO, which owns the invention, is the least knowledgeable actor in a licensing relationship. This informationally-disadvantaged position can foster ineffective decision-making, unreasonable demands, and/or procrastination. The understandable reaction on the part of inventors will promote grudging cooperation or efforts to use the gray market – an illegitimate strategy that is easily actualized. In summation, the current university ownership model is characterized by perverse incentives and a lack of enforceability.

The university ownership TLO model is built on a linear, over-the-transom model of innovation in which the inventor invents, the TLO licenses, and the licensee commercializes. The literature clearly shows that this conceptualization is incorrect as interaction between the inventor and licensee are critical, and the TLO's role is frequently

reduced to extracting rents from the invention. The only case in which the TLO adds value transpires when it is a broker connecting the two parties – a case in which university ownership is unnecessary. Intensive qualitative studies, such as Mody's (2006), of university invention-based firms have shown that new firms have their roots outside the university's institutional arrangements for transfer. The patent and TLO model currently practiced at nearly every U.S. university is not necessary for entrepreneurship (See also Colyvas et al. 2002; Owen-Smith 2005).

Our two alternative models differ radically from the current one in dealing with the diffusion of university inventions, inventor ownership, and open source. Each of these alternatives, as is the case with university ownership, is the result of different visions of the social good, technology diffusion, and the public purpose. In the first case, the invention would remain the property of the inventor or inventors to commercialize or dispose of through any solution including open source. This model places the inventor, someone very knowledgeable about the invention, in the position of deciding the proper approach to commercialization. If there is a normative argument for rewarding the university, we suggested that the university could be compensated with a small non-dilutable, silent partner stake in all ventures that professors may undertake in their fields of expertise. The university's role would be to ensure that the commercialization process was honest and transparent. To improve the process further, it might be advisable to appoint a University Commercialization Ombudsman, who would be a faculty member who had a profile of proven success in commercialization. This person would not represent the university, but rather would assist and advise the inventor on how to create the firm within the rules and norms of the university. Such a solution need not lead to the

abandonment of the university TLO, as it could offer its services to the inventor for a fee. The university TLO would be placed on a self-supporting basis. Good TLOs would likely survive and thrive, although those that provided low quality service would be less successful. Inventor ownership would not be a panacea, but we have made a case that it would be superior to the current model.

The open source or non-exclusive license model is also attractive. It escapes the entire problem of inventor ownership by stipulating that university inventions would not be owned at all or would be licensed to all users. For most inventions, this arrangement would be effective and efficient. It is possible that many inventions may leave the university through the gray market, but outflow is already an issue. In this case, the administrative issues regarding commercialization are eliminated entirely.

As Etzkowitz (2002), Rothaermel et al. (2007), and Shane (2004) have shown, university-industry relationships and academic entrepreneurship is a burgeoning field of research, though there has been less research on alternative models for organizing the commercialization of university inventions. Also, in terms of the history of how the B-D model developed, more can be done to build upon the path-breaking research by scholars such as Mowery et al. (2004), Eisenberg (1996) and Rai and Eisenberg (2003).

One area of interest is how key technology licensing personnel and their professional organization, the Association of University Technology Managers (AUTM), shaped the current system through political action and operational decisions that framed what has now become an institutionalized model.⁴⁰ AUTM and TLO employees from various universities, though stating that they do not represent their universities, appear to

⁴⁰ A classic explanation of interest group politics is Lowi (1979). On institutionalization and diffusion of social models, see Tolbert and Zucker (1996);

be speaking for the university when they testify and lobby for an ever more restrictive patent model, which Jaffe and Lerner (2004) criticize as inhibiting innovation and commerce.⁴¹ This desire for an ever more restrictive patent regime is the direct result of the university's status as a non-profit organization, which no research university would like to relinquish, and the university's structural inability to commercialize inventions directly. For this reason, university TLOs find their economic interests aligned with and, in some cases, operate as "patent trolls," even while the university is dedicated to and predicated upon free flows of information.⁴² Such archival research could help answer the question of how such a small unit within universities developed such salience in defining the way in which commercial knowledge is transmitted to the greater economy.

This article examined the foundations of the university ownership model and built the case that the model itself is fundamentally flawed. We proposed two quite different new foundations for handling university inventions. In part, we reacted to the triumphalism with which the university ownership B-D model has spread globally. Apparently, some policy-makers now subscribe to a cargo cult-like belief that passing new regulations mimicking U.S. models will deliver entrepreneurship and new "Silicon Valleys," even to the point that the most successful university technology-based entrepreneurial region in the world outside the United States— Cambridge, England—abandons its successful model. Such beliefs are epitomized in an OECD (2003) paper finding that "one of the most urgent tasks is still to raise awareness of and support for university patenting and related activities." Since the last word on this topic has not been written, this paper should be taken as an invitation to a debate about how to

⁴¹ Jaffe and Lerner (2004) is a detailed indictment of what they believe is a patent model that is too tilted in favor of the patent holders.

ensure the greatest social good is derived from the knowledge and inventions created in universities.

⁴² For a discussion, see De Larena (2006).

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