Incentives or Resources? Commercialization of University Research by Start-Ups vs. Established Firms

Brent D. Goldfarb
Robert H. Smith School of Business
University of Maryland

Rachelle C. Sampson
Robert H. Smith School of Business
University of Maryland

Arvids A. Ziedonis
Lundquist College of Business
University of Oregon

This version: January 22, 2011

Abstract

The commercialization of scientific research performed at U.S. universities since the Bayh-Dole Act of 1980 has increasingly been governed by licensing contracts between universities and private firms (Mowery, Nelson, Sampat, and Ziedonis 2004). A number of scholars have examined factors that influence whether an established firm or start-up venture would be better positioned to develop and introduce a university invention to the market (e.g., Shane 2001, 2002; Shane and Nerkar 2003, Lowe and Ziedonis 2006). Other scholars have examined the design and structure of licensing contracts governing the commercialization of university research (e.g., Thursby, Thursby, and Dechenaux 2005; Elfenbein 2004). In this paper we combine these two fundamental aspects of the commercialization process to investigate the effect of the licensee choice (whether the commercializing firm is a start-up or established firm) on the structure of the license. We recognize that organizational risks presented by start-ups and established firms differ; comparatively, start-ups bear a greater risk of firm failure, whereas commercialization incentives in established firms may be weaker. Using data from over one thousand technology licenses at a leading university licensor, Stanford University, we examine how the choice of licensee (start-up or established firm) coupled with the characteristics of the licensed technology affect the structure of licensing contracts in start-ups and established firms. For start-up firms, we also examine the implications for license structure of the involvement of (a) a venture capitalist and (b) a university founder. Our results shed light on how license structure is used to control for technology and organizational risks, bearing implications for the role of licensee choice facilitating commercialization.

JEL Classifications: O31, O32, O34

Keywords: entrepreneurship, start-ups, licensing, technology commercialization

---

* Authors listed in alphabetical order. We are indebted to Katherine Ku of the Stanford University Office of Technology Licensing for generous access to data. We thank Janet Bercowitz, Pablo D'Este, Jenny Kuan, Joanne Oxley and Rosemarie Ziedonis as well as participants at the HEC Paris Workshop on Academic Entrepreneurship and seminar participants at Boston University, the University of Oregon, and the University of California, Berkeley for insightful comments.

1 Introduction

Basic scientific research conducted in university laboratories has long been an important source of technologies commercialized by private firms. For example, surveyed pharmaceutical industry managers reported that more than one quarter of new drugs commercialized would not have been developed or would have been significantly delayed without academic research (Mansfield 1991). Similarly, the well-known "Yale" (Levin et al. 1987) and "Carnegie-Mellon" (Cohen et al. 2002) surveys of industrial R&D executives identify the importance of university research on innovation within their industries. Moreover, surveyed managers in most industries surveyed by Levin et al. reported that they relied most heavily on scientific publications, conferences, informal interaction with university researchers for scientific information. In a much more recent study, Nelson (2010) finds that academic publications and hiring of graduate students are the two most prominent avenues by which the music industry benefited from research performed at the Center for Computer Research in Music and Acoustics at Stanford University, far outpacing the number of instances that firms became industrial affiliates or licensed specific technologies from Stanford.

Despite the multitude of channels by which industrial organizations have drawn on university research in the 20th century, patenting and licensing has become an increasingly important channel in the decades since the Bayh-Dole Act of 1980 (Mowery et al. 2004). Recent scholarly work has focused on the differences between established firms and entrepreneurial start-ups in their ability and performance in commercializing licensed university technologies (Shane 2001, 2002; Lowe and Ziedonis 2006). While identifying numerous factors likely to influence the choice by the university of an established or start-up licensee, these studies were unable to observe how the commercialization efforts by these two types of firms were governed through the licensing contracts with the university.

Start-ups and established firms each pose unique challenges to be overcome to successfully commercialize a licensed technology. Exploiting a comprehensive set of licensing contracts governing the commercialization of inventions discovered by researchers at Stanford University, we examine the organizational choice made by Stanford as to the type of licensee–start-up or established firm. We then recognize the endogeneity of this choice and consider how the selection of organizational form is related to contract design.

Our setting, the commercialization of research undertaken at Stanford University via licensing contracts, is ideal to address this issue for several reasons. First, in contrast to technologies discovered within the firm where the invention may be developed internally or shelved, the licensing event allows us to observe the decision to undertake development and commercialization. Second, the choice of licensee by Stanford depends largely on finding the firm best able to commercialize the technology, without regard to the competitive dynamics that likely play a role in such decisions when new technologies are discovered within firm.[1] Firms often seek to avoid creating competitors and often consider how related a technology is to their core abilities in considering whether to de-

[1]The stated goal of Stanford's Office of Technology Licensing is to develop products that benefit the public (Leute, 2005).

velop the new technology or not. Finally, we can observe licensing provisions employed to address organizational risks in technology commercialization.

A goal of this study is to further our understanding of a question receiving little attention in the literature, namely how organizational form and intellectual property protection affect the commercialization of technologies, as opposed to their discovery. Since the seminal work of Arrow (1962), much attention has been paid to the role of intellectual property in encouraging and facilitating discovery. Less attention has been paid to the technological development and commercialization process (Hahn, 2003).[2] While previous studies have identified mechanisms used by university licensors to address developer effort and related shelving issues (Thursby et al. 2005; Hegde, 2010), to our knowledge there is no prior research examining the terms used in start-up licenses to address specific organizational risks that start-up licensees pose, particularly as compared to established firm licensees. The closest study to ours is Elfenbein (2004), which compares the effect of several different terms on early termination between large and small firm licensees. We also note that most studies examine only exclusive licenses (Elfenbein 2004, Thursby, et al. 2005, Somaya et al. 2011) and often only patented inventions (Shane 2001, 2002; Elfenbein 2004; Hegde 2010). We are able to observe both patented and unpatented inventions, and both exclusive and non-exclusive licenses.

A complementary line of reasoning explores the question of which technologies will likely be commercialized by start-ups and which by established firms (Shane, 2001, 2002). This literature, in part based on Teece's (1986) insight that complementary assets often play a critical role in successful commercialization, has explored the role of intellectual property right protection on successful commercialization. Building on this seminal work as well as Arora et. al (2001), Gans, Hsu and Stern (2003) argue that intellectual property protection facilitates the market for technologies, enabling start-up commercialization when intellectual property protection is strong. Whether or not a technology is commercialized by a start-up firm appears to depend upon appropriability regimes and the nature of complementary assets (Gans and Stern 2003; Shane 2001, 2002).

Schumpeter's work exemplifies this tension as well (i.e., Schumpeter 1934; 1942). Whether a start-up or incumbent firm is best positioned to commercialize a technology depends in part whether strong commercialization incentives or available organizational resources (e.g., complementary assets) are relatively more important for commercialization success of a particular technology. Start-up firms have very strong incentives to commercialize new technologies and are unlikely to shelve them, as may established firms, but start-ups often lack slack resources and relevant complementary assets for successful commercialization. [3] There is thus is a fundamental tension between incentives and

[2] The strategic nature of the commercialization process has been analyzed by a few notable exceptions, however. For example, Lilien and Yoon (1990) and later Bayus et al. (1997) demonstrate that firms may delay commercialization under certain conditions. In more recent work, Dechenaux et al. (2008) consider whether the strength of different appropriability mechanisms affect the likelihood of commercialization of MIT technologies.

[3] Shelving refers to a situation where a firm licenses with (a) the intent to not commercialize the licensed invention and prevent others from doing so, or (b) the initial intent to commercialize the invention, but subsequently decides to not commercialize the invention after devoting resources towards development (Thursby, et al. 2005).

resources in not only technology discovery, but also commercialization.

We begin by examining which technologies are likely to be commercialized via start-ups or established firms. In our study, we largely confirm Shane's (2001, 2002) findings in our initial analysis. We then present novel findings on the match between technologies and licensees. We then estimate the relative level of organizational risk (i.e., the risk of shelving vs. the risk of firm failure) as well as technology risk (i.e., the novelty of the technology, need for complementary assets, and whether the market is developed or ambiguous). Our prior belief is that the greater the technological risk, the lower the likelihood of commercialization success. We can then show the organizational mechanisms designed to mitigate these risks and, ultimately, measure the effectiveness of these mechanisms via commercialization success as measured by royalties paid. We thus examine the effect of two key decisions on commercialization success: (1) the choice of licensee, given the technology; and (2) the choice of license terms, which we view as attempts to mitigate various risks associated with the licensee/technology pair.

In the next section, we consider the commercialization decision, specifically the influence of technology characteristics on whether the licensee is likely to be a start-up or established firm. Conditional on a match between the technology and firm type, we then estimate the technology and organizational risk associated with a licensed technology. In Section 3, we examine contract terms that can be used to attenuate these risks and the implications for performance (i.e., commercialization success) of the use of particular terms in response to risk types (matching of terms with risks). We assume that Stanford chooses terms to increase the probability of commercial success, which we will test in future research. Sections 4 and 5 describe our data and research design in detail. We discuss our results and their implications in Section 6.

2 Organizational and Technological Risks

Start-ups and established firms are each potential vehicles to take a new discovery from research laboratory to the development or commercialization phase. Both types of firms have been active in bringing university research to the market. Which type of firm would be the most effective licensee is a function of both organizational characteristics (e.g., the resources required to successfully develop a new technology and the incentives to do so) as well as technology characteristics (e.g., whether complementary assets are required and the degree of market and technological uncertainty).

The characteristics of the licensee firm, particularly whether the firm is established or a start-up, lead to organizational risk, or the risk that a firm will fail to commercialize a technology even when the technology is ripe for such commercialization. These risks come primarily in three forms: (1) the firm exhausts its resources before successful commercialization occurs, (2) the firm itself fails or exits, and (3) the firm lacks sufficient incentives to commercialize the technology (due to competing priorities or other competitive considerations, for example). While any of these modes of failure could conceivably occur in any firm, the first two risks are more common in start-ups and the third is more likely in the established firm.

These risks are similar to those originally posed for innovation more broadly by Schumpeter (1934, 1942). Schumpeter argued that large firms are more likely to enjoy economies of scale in R&D, better able to spread the risk of R&D activities, and have superior access to financial resources than smaller firms (Schumpeter 1942). Small firms (including start-ups), however, are typically not burdened by hierarchical incentive failures, coordination difficulties and bureaucratic sluggishness (Scherer 1992: 1422; Schumpeter 1912). The fundamental tension thus is between the need for resources for development and the incentives for development. How this tension is resolved is the subject of much empirical research on the relationship between firm size and innovation (see Scherer 1980 for a review). Empirically, it appears that small firms realize a greater number of innovations per research dollar, but large firms may still have an R&D advantage in the sense that these firms can spread the costs of development over greater output where these firms have developed markets (Cohen and Klepper 1996).

More recent research emphasizes that who is more likely to commercialize a new technology depends on how the functioning of the "market for ideas." Gans and Stern (2000) argue that incumbents generally earn greater returns to R&D via direct commercialization of discoveries, whereas entrants earn their returns primarily through contracting or licensing with an incumbent firm when intellectual property protection is strong. Instances of entrant competition are suggestive of the inability to successfully fashion a contract or license between a potential entrant and an established firm (e.g., a failure in the market for ideas). This analysis suggests that established firms are more likely to commercialize new technologies than entrants, particularly in the presence of strong intellectual property rights that support the market for ideas (Gans, Hsu, and Stern 2002). Established firms are also more likely to commercialize new technologies when the cost of acquiring the necessary complementary assets is high (ibid).

Shane (2002) explores several factors related to commercialization environments. He finds that start-ups are more likely to commercialize newer technologies or those that address a smaller, segmented market. In either case, one might expect large firms' complementary assets to be less important. Levine (2009) finds that market size is a very good predictor of whether a small pharmaceutical firm will market itself a drug it has developed. When markets are small and a limited number of doctors treat a particular disease, a firm is much more likely to develop its own marketing and sales capabilities. When the drug serves a common disease category treated by a large number of doctors, the small firm will instead tend to outsource these activities.

University inventions are often licensed in an embryonic state (Jensen and Thursby 2001), thus significant technological development is likely to occur within the duration of the license. Whether the licensee is a startup or established firm may therefore be as much a function as the optimal location for development as opposed to the optimal location for ultimate commercialization. Shane (2001) finds that at the Massachusetts Institute of Technology (MIT), start-ups were more likely to be the licensee when the licensed technology is more radical, important and broader in scope, or when patent rights in the firm's industry are strong (Shane 2002). Existing complementary assets are likely to be less useful in the commercializing a radical technology, thus mitigating the advantage in being selected as the licensee that an established firm may enjoy.[4] Shane's results do

[4]Shane (2001, 2002) does not analyze the relative propensity to license to startups or established firms.

suggest that strong patents lead to greater start-up licensing. Lowe (2005), as well as Goldfarb (2005) suggest that if the university inventor's effort is necessary for successful development, it may be difficult for large firms to provide sufficient compensation to inventors to induce such effort. Gans, Hsu and Stern suggest, however, that ultimate commercialization may occur within an established firm, particularly, when strong property right protection facilitates the market for ideas, thus making it easier for a start-up to "cooperate" by licensing a technology to the established holder of complementary assets rather than compete directly. Lowe and Ziedonis (2006) found that inventor-founded start-ups licensing inventions from the University of California often were acquired by established firms just prior to product market entry. It may be therefore that even within a strong intellectual property regime, development may occur under the guise of a start-up license, but ultimate commercialization is undertaken by an established firm through sub-licensing by the start-up or subsequent acquisition after the market is better defined (Bloningen and Taylor 2000, Lowe and Ziedonis, 2006).

Given these factors and absent other competitive considerations, the choice of licensee is a matter of identifying the best development environment (if needed), then subsequently resolving whether this firm is best suited for commercialization or if there should be an expectation of subsequent licensing to a third party. Prior studies have identified several risks facing the university in its licensing decision. There is the risk that a firm will license a technology but then shelve it either due to competitive considerations—for example, the technology competes or potentially cannibalizes the firm's existing technologies, or the firm may want the license the technology simply to prevent competitors from doing so (Thursby et al., 2005). One might expect an established firm to pose a greater shelving risk than a startup whose survival will be more likely to depend on the successful development of a single licensed technology.

Licensing to start-ups present other risks, however, notably the risk of organizational failure—either the start-up fails outright or is unable to obtain the resources necessary for development and commercialization. The university licensor must therefore balance the different organizational risks posed by established or entrepreneurial potential licensees.[5]

Commercialization success also depends critically on the characteristics of the technology being licensed. New discoveries range from conceptual ideas, far from prototype, to fully developed new products or processes that are close to the market (Jensen and Thursby 2001). Similarly, markets for a new product or process may or may not currently exist. Greater technology risks decrease the likelihood of successful commercialization, regardless of the licensee type.

In our context, the Stanford Office of Technology Licensing (hereafter, the "OTL") weighs both organizational and technology risks in licensing a new technology. Our conversations with licensing professionals at the OTL reveals that Stanford typically chooses an established firm over a start-up for commercialization if an appropriate established

Rather, he predicts the number of startups that license each patented invention–without regard to the number of established firms that also license the invention. It is unclear if the *share* of overall licensees that are startups follow the same pattern.

[5]Note that this is not simply a matter of asymmetric information. It is quite possible, perhaps likely that neither the licensor nor the licensee understand *ex-ante* the ability of the new start-up to navigate potential organizational risks (Jovanovic 1982).

firm can be found. We therefore assume that the OTL prefers an established firm to a start-up, suggesting that the consequence of organizational failure or lack of complementary assets by a start-up is greater than the risk of shelving by an established firm. Interested and qualified established firms are not always available, however. Start-ups then emerge as likely licensees, particularly for nascent, risky technologies (consistent with Bloningen and Taylor 2000, Shane 2001, 2002; and Lowe and Ziedonis 2006). The question then becomes how license terms, or organizational form, can be used to address resultant organizational and technological risks.

3 Licensing under Technology and Organizational Risk

Three primary mechanisms are frequently utilized to address technology risk associated with licensing a new invention—exclusivity, running royalties, and equity stakes in the licensee firm. Exclusive licensing is often offered for very nascent technologies—ensuring that competitors will not also have access to the licensed technology provides the licensee incentives to invest in commercializing early stage inventions (Gallini and Wright 1990, Thursby et al., 2005, Somaya et al. 2011). We therefore expect to observe exclusive licensing when technological risk is significant. Early technologies may also require significant transfers of tacit knowledge by the inventor directly to the firm to improve commercialization prospects (Agrawal 2006). In such a scenario, licenses can be structured to include terms that align the incentives of the inventor with the firm, such as higher royalty rates and/or equity stakes in the licensee firm (Gallini and Wright 1990, Hegde 2010). Lowe (2006) and Goldfarb (2007) suggest that in cases where tacit knowledge transfer is important, strong incentives are effective in encouraging inventor effort—which implies that commercialization is more likely to take place in a startup.

Royalty rates are generally thought to increase with the hidden quality of the invention (Gallini and Wright 1990, Hegde 2010), since shifting payments to the inventor later in the commercialization process ensures that the inventor has the incentive to stay engaged throughout development. Royalty rates require a good sense of the nature of the end market, however, thus reflect a degree of contract completeness that may only be feasibly for technologies with sufficiently low market ambiguity—which may be more likely for easily purposed or later staged technologies. The taking of equity stakes in the licensee has a similar effect, ensuring that commercialization success is in the best interests of the inventor.

Some of the mechanisms used to address technological risk may exacerbate organizational risks, however. For example, while exclusivity is often required to deal with technological uncertainty, granting such a monopoly increases the risks of shelving or delay in commercialization (Thursby et al., 2005). Shelving is more likely by established licensees with potentially cannibalized products, however. Start-ups are less likely shelve a licensed technology, as successful commercialization is important for firm survival. Similarly, higher royalty rates have distorting effects, creating incentives for firms to decrease output (Gallini and Wright 1990).

Many licensors are aware of these issues, however, and have designed mechanisms to address these increased organizational risks. Upfront fees may decrease shelving (Hedge

2010), but such fees are often used in lieu of higher royalty rates, which then dampens inventor incentives to transfer tacit knowledge. A potential solution to this dilemma is posed by Thursby et al., (2005), who argue that a combination of milestone payments and annual fees solves the shelving problem. Milestone payments, or payments on achievement of specific commercialization objectives, do not distort output in the way royalties can and preserve incentives of the inventor to contribute (Bousquet et al., 1998). Annual fees, or payments not tied to output or commercialization milestones, encourage the licensee to either develop the technology or to return the technology to the licensor. Diligence clauses, or non-financial requirements to achieve development milestones by a particular date, are also a means for the licensor to monitor progress and terminate the license if the firm is not taking steps to commercialize. While these organizational risks of shelving and lack of incentives to develop a particular technology are possible in both established and start-up firms, we expect these risks to be greater in established firms (as argued above). Thus, we expect to observe diligence clauses and annual fees in licenses to established firms more frequently than in licenses to start-up firms.

Jovanovic (1982) suggests that entrepreneurs enter without knowledge of their abilities in the market. If so, we should expect diligence and milestone clauses not to provide mechanisms to revoke licenses in case of moral hazard, but instead to provide mechanisms to revoke licenses in the case of business incompetence. Additionally, it is possible that startups may agree to more draconian terms as a signal–only firms with a great deal of confidence of their own abilities would agree to such terms (see Dessein 2005 for a similar argument in the context of venture capital contracts). However, such uncertainty about business competence is less plausible in the case of licensing to established firms with known track records. Hence, milestone payments that would work to combat moral hazard may be more likely with licenses to established firms whereas diligence clauses may be more likely with startups.

In contrast, milestone payments should be common among both start-up and established firms, since they both preserve inventor effort (important for both types of licensee) as well as and deal with possible risk aversion of the licensee in developing an early technology. In this sense, while milestone payments address organizational risks, they also deal with technology risks. We would expect milestone payments to be more likely the farther from commercialization is the licensed technology. Milestone payments also can address an organizational risk more common in start-ups—that the licensee will lack resources necessary to commercialize the new technology. By tying license payments to commercialization in lieu of annual fees and effectively deferring these payments until some development objectives are achieved, the start-up will be left with greater resources to invest in commercialization early in this process.

Other mechanisms that may address organizational risks more common to start-ups (firm failure and lack of resources to commercialize) include equity as a more significant portion of royalty payments, specific diligence clauses tied to organizational milestones, such as achievement of venture capital funding, and exclusivity. Equity, in lieu of royalty or other cash payments, preserves resources of the start-up for commercialization efforts, while aligning the incentives of the inventor with the start-up as mentioned above (Feldman et al., 2000). We also expect specific diligence clauses to be more common in licenses to start-ups, as a reflection of the organization risks unique to such firms. One illustration of such a clause would be a requirement to achieve venture capital funding by a specific date.

Finally, exclusivity to keep competitive pressures at bay may be relatively more important for start-up firms as they develop any necessary complementary assets. We thus expect to see exclusivity more commonly in licenses to start-up firms than to established firms. Note, however, that we also expect start-ups to be licensed the most risky and nascent technologies, due to the fact that established firms are often reluctant to license such technologies and may prefer to wait to acquire the start-up or sub-license from the start-up once the technology is better developed (Lowe and Ziedonis 2006). This would lead to greater use of exclusivity in start-up licenses–especially if property rights are strong–as it would allow further trade in downstream technology markets once the technology is further developed.

In essence, we expect that careful use of these terms may lower commercialization risks set by the technology-firm pair. In this sense, the license contract moderates the effect of the technology-firm pair on commercialization success.

4 Data and Sample Description

Our data come from a comprehensive sample of 1,819 technology licensing contracts for technologies emanating from Stanford University, a major private research institution in the U.S. The Stanford OTL was officially established in 1970 and since that time has been one of the most successful university licensing offices in terms of licensing revenue (Mowery et al., 2004). The Stanford data include emblematic licenses (e.g., licensing of Stanford logos and images for collegiate wear), options, material transfer agreements, as well as licenses for new technologies. We focus on newly developed technologies and exclude the other agreements from our sample. For each remaining license in the sample, we observe the entire license agreement, enabling us to examine the pricing structure (i.e., upfront fees, annual fees, milestone payments and running royalties), prices (i.e., royalty rates) and other mechanisms influencing incentives and directing actions by the licensee (e.g., diligence clauses and exclusivity). Table 1 provides brief exemplars of coded terms. To date, we have coded terms in 1,481 licenses. We excluded licenses for which we were unable to identify the underlying technological area, reducing our sample size to 852 agreements. While the data cover licenses beginning in the early 1980's, we have a relatively small sample of these early licenses and thus focus our current analysis on licenses executed from 1990-2004.

*** Table 1 Here ***

We utilize OTL classifications of each licensed technology, such as whether the new invention is a product or process innovation, a drug or medical device, whether the research underlying the invention was federally funded. Through the OTL we were also able to identify the academic department and number of past discoveries disclosed by each inventor, as well as the number of inventors for each new invention. Finally, we identified the technology area of the licensed invention (i.e., the industry), coded the effectiveness of each industry's appropriability regime (Cohen et al. 2000), and added industry concentration from the US Census of Manufacturers (1997, 2002). Table 2 describes these measures.

*** Table 2 Here ***

We utilized several sources to identify founding years for each of the licensees, including Factiva, offices of Secretary of State, VentureXpert, Zephyr (Bureau Van Dijk) and the Office of Technology Assessment report entitled *Commercial Biotechnology: An International Analysis* (Chapter 4, Firms Commercializing Technology).[6] We code firms with founding years one year prior to the license date or later as start-ups.[7]

Invention characteristics for the full sample and for the start-up and established firm subsamples is reported in Table 3 and characteristics of the inventors are contained in Table 4.

*** Table 3 and Table 4 Here ***

We also report these characteristics split by exclusive and non-exclusive licenses, given that exclusive licenses likely reflect differences in underlying technologies (e.g., exclusive licenses may be associated with the need to develop more complementary assets) as well as driving organizational risks (e.g., exclusive licenses are much more prone to shelving for competitive reasons than non-exclusive). Tables 5 and 6 report invention and inventor characteristics for exclusive licenses and Tables 7 and 8 report these characteristics for non-exclusive licenses.

*** Tables 5, 6, 7, and 8 Here ***

Table 9 describes the licensing firms, and Table 10 reports characteristics of the licenses in the sample.

*** Table 9 and Table 10 Here ***

Tables 11 and 12 report licensee and license characteristics for exclusive licenses and Tables 13 and 14 report these characteristics for non-exclusive licenses.

*** Tables 11, 12, 13, and 14 Here ***

Comparing our data to those utilized in past studies, we note several important differences. Our sampling frame is different compared to several past studies involving university licensing such as Thursby and Thursby (2002), Dechenaux et al. (2009), Shane (2001, 2002), and Elfenbein (2004). Our sample is significantly broader than those in earlier work; we include both non-exclusive licenses as well as unpatented inventions. Frequencies set out in Table 10 reveal that 41.9% of our licenses are exclusive (vs. 100% in

[6] Available at http://www.princeton.edu/~ota/disk3/1984/8407/8407.PDF

[7] Note that the license date is the earliest date of the following three: date signed, date effective and date entered as written either on the contract itself or maintained in the OTL's records. The most commonly used date is the effective date.

the above studies). The proportion of exclusive licenses at Stanford is slightly lower than recently reported by the Association of University Technology Managers (AUTM) as typical, whose surveys suggest that approximately half of university licenses are exclusive, and significantly less than the 75% exclusivity reported by Thursby and Thursby (2002) and Jensen and Thursby (2001).[8] This contrast may reflect university differences in licensing approaches between Stanford and other universities or differences in the underlying discoveries themselves.

Patenting rates in our sample also differ from earlier work; only 43.7% are patented in our study, versus 100% in several earlier studies (based on sampling choice, not the population (e.g., Elfenbein 2004; Shane, 2001, 2002). We note that the approach of the Stanford OTL in most cases is to submit a patent application after a suitable licensee has been identified. This strategy contrasts with the MIT approach noted in Shane (2001)—MIT will often patent on speculation before suitable licensees have been identified.[9]

Table 4 reports that the licensed inventions in our sample are largely federally funded (67.1%), involve research tools (69%), and are bio-medical inventions of some kind, either medical devices or drugs (66.9%).[10] Most of the licensed discoveries are made by inventors who have previously disclosed inventions. Consistent with the high share of biomedical inventions, 59.4% of inventors are affiliated with the Stanford School of Medicine. The department with the second highest number of inventions is electrical engineering (16.3%).

These inventions are typically licensed to small firms (58.4%), defined as firms with fewer than 500 employees. Only 20.1% of inventions are licensed to start-up firms, which is roughly equivalent to the proportion of inventor founded firms (19.2%). Note that this does not imply that all start-ups are inventor-founded; roughly 47.4% of start-up firms in the sample are inventor founded.[11]

<u>License Terms:</u> Start-up licenses appear to have a greater number of diligence terms than do licenses to established firms, though these terms are utilized in fewer than 35% of licenses). This is surprising since we would expect that diligence terms would be com-

[8]Association of University Technology Managers, AUTM Licensing Survey (FY 1991 and FY 2001).

[9]Stanford's approach suggests that a smaller fraction of invention disclosures by its faculty will be patented at Stanford than at MIT, but also raises an interesting issue—all of the patents in our sample are for licensed inventions. Suitable licensees have been found for all inventions in our sampling frame (since we are analyzing only licensed inventions), yet fewer than half of these inventions have associated patents. This suggests that either (a) the samples used in studies of only patented inventions may be less representative than previously thought, or (b) the underlying technologies at Stanford differ dramatically from those at other universities such as MIT in the sense that they are less 'patentable.' One explanation could be that Stanford's pool of invention disclosures is more highly represented by software than disclosures at other universities. (Mowery et al., 2004 report that Stanford is a significant licensor of software.) While software patenting has increased dramatically in recent years, rates of patenting on software are lower than for inventions in other technological areas.

[10]Mowery et al. (2001) report that biomedical invention disclosures as a share of all disclosures at Stanford rose sharply in the late 1970s and that by 1990 the share of licensing agreements by biomedical inventions was slightly more than 70%.

[11]Established firms were also founded by inventors in some cases (12.2%). This number likely reflects firms that repeatedly license from Stanford—a faculty inventor creates a firm, licenses one technology, later creates another technology and then licenses that new technology.

monly utilized to discourage shelving, a problem more likely in established firms. It could be that issue fees and, to a lesser extent annual minimum royalties, which are commonly used in both start-up and established firm licenses, are sufficient to deter shelving.

However, these data may have nuances that these descriptive statistics do not capture. For example, the timing for payment or amounts due may be very different for these same clauses between start-ups and established firms. Issue fees or minimum annual payments may be higher for established firms than for start-ups and this increased magnitude may compensate for the increased risk of shelving or delay.

Overall, seventy percent of these 852 licenses include issue fees, 37.7% include output based royalty fees, 46.8% include annual fees, 16.7% include progress or milestone fees, 22.9% include patent reimbursement fees, 10.7% are equity licenses and 41.9% contain exclusivity clauses.

Start-up firms are more likely to obtain an exclusive license than are established firms, perhaps in recognition of the heightened organizational risk if the license is non-exclusive and other firms license and develop the same technology. Non-exclusive licenses may also control for the risk of shelving or delay by established firms. However, we note that the underlying technology licensed to start-ups versus established firms may drive this difference in exclusivity. To further explore the differences between exclusive and non-exclusive licenses, we further split the sample by exclusivity and generate descriptive statistics for both the start-up and established firm subsamples.

We complement the coded license terms with additional data on the underlying technology, using patent information (where a licensed technology was patented prior to license), as well as information on the licensee from Dun and Bradstreet and CorpTech, and founding years from the sources described above.

5 Methodology

Identifying how organizational type (i.e., start-up or established firm) affects the contractual terms of university licenses in ways not otherwise predicted by the technology being licensed is a difficult empirical exercise. Fundamentally, we seek to identify how license terms are selected to simultaneously address both technological and organizational risk. To disentangle these two dimensions, we proceed in two steps.

In the first stage, we establish a level of technology risk for each discovery. Ideally we would observe the stage of technological development at the time of license. For example, in the 1997 AUTM Survey, respondents reported seven different classifications of maturity ranging from"proof of concept but no prototype" to "ready for practical or commercial use" (Jensen and Thursby 2001). Unfortunately, the Stanford OTL did not monitor the stage of development for invention disclosures in our sample thus we have no such detailed measure. We instead crudely measure technological maturity based on the age of the disclosure at the time of license. Since prior research suggests that the most nascent and risky technologies are often licensed to start-up firms (Shane 2001), we then estimate the probability that the licensee will be a start-up (versus an established firm) based on the age of technology and other industry specific measures, as suggested by prior research (Shane 2001, 2002). Due to the dichotomous nature of the dependent variable (whether the technology is licensed to a start-up or not), we utilize a probit model for this estimation. We then use the variables identified as strongly correlated with the probability of licensing to a start-up as a signal of earlier-stage technologies.

We then assume that the type of licensee, that is, a start-up or established firm, proxies for the organizational risk associated with the license. Shelving risks are assumed to be relatively stronger in established firms, while start-ups are relatively more prone to organizational failure. Finally, we examine the license terms selected for each license, having categorized the levels of technological and organizational risk. While we have some expectations about when particular license terms are used (e.g., Hedge 2010), we know less about the portfolio of terms used in conjunction with different technologies and firms. For this reason, our approach is somewhat inductive at this stage. We use descriptives, basic probits and cluster analysis to identify how terms are used in conjunction with one another and with particular licensees/technologies. Specifically, we examine whether licenses include exclusivity, upfront fees, royalties, annual minimums, equity patent reimbursements and different types of diligence clauses. Our assumption is that the terms selected for a particular license are so chosen to maximize the probability of commercialization success.

6 Results and Discussion

6.1 Probit Analysis:

We first examine the factors that are correlated with licensing to a start-up firm. Table 15 reports a probit analysis where the dependent variable equals 1 if the licensee was a start-up, 0 otherwise. The first model includes characteristics of the invention. The second model adds inventor departments and the mean number of inventions per inventor for the licensed technology. Finally, the third model adds industry characteristics, including survey findings from the Carnegie Mellon survey on the relevance of intellectual property protection. We repeat these models on two subsamples, exclusive and non-exclusive licenses, to allow estimates to vary between these two potentially distinct types of license.

*** Table 15 Here ***

From Model (1) of Table 15, we see that start-ups are less likely to be the licensee in medical technologies as well as in consumer products. Start-up firms are also less likely to be the licensee for inventions that are already patented at the time of license, though this effect is not significant in the full sample. Research tools are also less likely to be licensed by a start-up. Because research tools often require little development and are typically licensed widely on a non-exclusive basis (Ziedonis 2007), such technologies are likely to be of little interest to entrepreneurs. Start-ups appear to be as likely to license software technologies invented at Stanford as they are to license inventions arising from federally funded research.

Model (2) of Table 15 includes inventor departments, a control for the number of inventions for each faculty inventor listed on the invention disclosure and the number of inventors on the team. Departmental affiliations appear to have little effect on whether a start-up firm or established firm will be the licensee, with the exception of inventions disclosed by faculty in the computer science department. Those inventions are less likely to be licensed by a start-up firm. Start-up licensing is similarly less likely when inventors have a greater number of prior inventions. If prior inventions are licensed and later inventions are related technologically to these earlier licenses, then we might expect the same (now established) firms that licensed before to be interested in also licensing these later technologies. Finally, new technologies are more likely to be licensed to a start-up when these technologies are developed by a larger group of inventors. Larger inventor team size is thought to be correlated with underlying value of inventions, since such inventions by definition require greater resources to develop. Possibly, inventors may be more interested in commercializing more valuable inventions themselves, which would lead to greater start-up licensing, presumably to inventor-founded firms.

When we add industry characteristics and control for the "boom" years of 1999-2000 in Model (3), we find that start-ups more likely to be licensees in industries where patenting is an effective appropriability mechanism. Strong patent protection would allow to start-ups compete more effectively with established firms possessing greater resources that could otherwise be used to imitate quickly. This result appears to be inconsistent with the finding that startups are less likely to license patented inventions. One explanation could be that startups often license early-stage (and unpatented) technologies. If the start-up fails, Stanford would likely not pursue a patent unless it has identified another licensee willing to pay for patent prosecution costs. It is also possible that the patent effectiveness is capturing another (unmeasured) industry characteristic.

Start-up licensing is more prevalent during the years 1999-2000, which is not surprising given the availability of venture capital funding during that period. Start-up licensing is also more prevalent in concentrated industries, a finding inconsistent with Shane (2001). Signs and significance levels of the remaining variables are relatively unchanged between Models (1) and (2).

Splitting our sample into exclusive and non-exclusive licenses adds some nuance to the above discussion. With the exception of inventions out of the computer science department, which are absent from the non-exclusive license sample, the effects discussed above appear to be largely driven by non-exclusive licenses. For example, medical and research tool inventions are less likely to be licensed to start-ups, but this effect is only significant for non-exclusive licenses. Patented inventions are similarly significantly less likely licensed to start-ups, but again largely in non-exclusive licenses. In contrast with the full sample results, however, older technologies are more likely to be licensed to start-ups in non-exclusive licenses, in contrast with technologies licensed through exclusive licenses. Further, patented inventions are less likely licensed to start-ups in non-exclusive licenses. Non-exclusive licenses to start-ups are more likely inventions from electrical engineering and are more likely to have inventors outside of Stanford on the invention. Finally, non-exclusive licenses more likely to be licensed to start-ups during the technology bubble, 1990-2000.

*** Table 16 and Table 17 Here ***

These findings suggest a more nuanced relationship between technology maturity and licensing to start-up firms. While our full sample results are broadly consistent with

Shane (2001) in the sense that patented (i.e., more mature) technologies are less likely licensed to a start-up, this effect is largely driven by non-exclusive licenses, a category of licenses not included in Shane's analysis. Further, our technology age variable is positively linked to start-up licensing for non-exclusive licenses. This may suggest that start-ups are more likely for more mature technologies in non-exclusive settings, where the organizational risks of both types of firm are mitigated by the ability to license to another firm, or that the risk of licensing to a start-up is less significant because the technology is more mature and less uncertainty surrounds its development prospects.

6.2 Cluster Analysis:

Having identified variables significantly correlated with start-up licensing, we now turn to the license terms used to control for the relevant technology and organizational risks associated with a particular license. Again, we assume that terms are efficiently chosen so as to maximize commercialization and, consequently, diffusion of the underlying technology. License contracts are multi-dimensional, embodying a significant variety of tools available to Stanford to meet its objectives. While we have access to the complete agreements of the licenses in our sample, we initially focus our efforts on several broad categories of license terms: whether a license is exclusive, whether royalties, issue fees, and/or annual minimum royalties exist, whether equity is granted in the licensee as part of royalties paid, whether patent reimbursements are offset against royalties, and, finally, whether and what type of diligence clauses are included in the agreement.

We expect that these terms are not chosen in isolation from each other, but rather are interrelated. For example, exclusivity raises the risk of shelving as well as the costs of organizational failure (particularly when licensing to start-ups). To compensate for exclusivity, Stanford may include terms such as annual minimum royalties (to prevent shelving) and/or diligence clauses that require frequent progress reports (to ensure that development is proceeding as expected). As such, we use cluster analysis to divide the licenses into distinct groups to analyze the simultaneous use of these different license contract terms. Cluster analysis has been used in a number of contexts to identify similarities in groups of observations across multiple dimensions (venture capital contracts (Kaplan and Stromberg 2003), and human resource management practices (Ichniowski, Shaw, and Prennushi 1997, for example).

We cluster on the license terms used, essentially developing groups of licenses that have common terms. We then examine differences in invention, inventor and licensee characteristics among clusters with a view to identifying complementarity of license terms and matching types of license contracts with types of inventions and licensee firms.

We use a partition cluster method ("*k*-means" cluster analysis) to separate the observations into a distinct number overlapping groups. With partition clustering, the number of groups must be specified.[12] We estimated two to six clusters and then selected the number of groups according to the values of the Calinski and Harabasz (1974) pseudo-F index;

[12]The clusters are formed iteratively; each observation is assigned to a group based on how close the observation mean is to the group mean. Group means are initially determined by k randomly chosen observations, where k is the number of groups selected. The group mean is then adjusted to reflect the inclusion of the new observation. This process continues until no observations change groups.

larger values indicate more distinct clusters. The largest value of this index was at three clusters. We report the results of this analysis in Tables 18 (invention characteristics), 19 (inventor characteristics), and 20 (licensee and license characteristics). [13]

*** Table 18, 19, and 20 Here ***

The three clusters break down along a few distinct lines. Examining first the differences between the clusters in terms of license terms (how the clusters were formed), we note that Clusters 1 and 2 are characterized by largely exclusive licenses. There are no exclusive licenses in Cluster 3. Of the "exclusive" clusters, cluster 2 has more exclusive licenses, while cluster 1 has more royalty clauses (76.6% vs. 47.5% in Cluster 2), including annual minimum royalties (82.1% vs. 41.5% in Cluster 2), milestone payments (39.3% vs. 26.5% in Cluster 2) and equity as part of the royalties (35.2% vs. 17% in Cluster 2). Interestingly, Cluster 1 (exclusive) has the highest incidence of diligence clauses (100% of these licenses have some form of diligence clause), while both Clusters 2 (exclusive) and 3 (non-exclusive) have few diligence clauses (3.5% and 3.8% of licenses, respectively). In contrast, there does not appear to be a significant difference between clusters in terms of the how frequently issue fees are used or which licenses have been terminated. Based on license terms alone, there appear to be two exclusive clusters, distinguished by diligence clauses and royalties, and one non-exclusive cluster, characterized by few diligence clauses and other differences in the royalty clauses (specifically, less use of equity, milestone payments, for example).

Based on these observations, we can identify complementarities among license contract terms. For example, patent reimbursements are common in licenses that are exclusive. This suggests a higher patenting rate for these licenses, which is confirmed in the Table 20; patents exist in 66.9% and 52.5% of Cluster 1 and Cluster 2 licenses, respectively, but only 22.3% of licenses in Cluster 3. This is consistent with expectations; exclusivity is only possible and valuable to the extent that intellectual property rights can be protected. Milestone payments are also more common in exclusive licenses in Clusters 1 and 2 (39.3% and 26.5% of licenses, respectively, versus 8.7% in Cluster 3).

Perhaps more interesting is to link the clusters of license terms with the underlying technologies and licensee characteristics. Focusing first on invention characteristics, we note that the average technology age is slightly higher for non-exclusive licenses than exclusive (2.858 years between disclosure and license for Cluster 3 licenses, versus 2.7 and 2.575 years for cluster 1 and 2 licenses, respectively). Research tools, software and medical inventions are much more common in non-exclusive licenses, than exclusive. Optical inventions are more common in exclusive licenses (13.8% and 11% for Clusters 1 and 2 vs. 2.4% for Cluster 3), as were consumer products (around 24% for exclusive clusters, 12.8% for non-exclusive). Consistent with these observations, 65.5% of inventors for Cluster 3 licenses are from the School of Medicine, while inventors from the Electrical Engineering Department are more likely associated with inventions in Clusters 1 and 2 (29.7% and 16% vs. 9.8% in Cluster 3).

[13]We note that the results from a larger number of clusters are very similar to that reported below. The main difference with, for example, four groups is that the non-exclusive group is split into two groups.

Licensees are significantly more likely to be start-ups, have venture capital funding and be inventor-founded in the exclusive Clusters, 1 and 2. Further, within the exclusive clusters, licensees are more likely to be start-ups, with VC funding and inventor founded in Cluster 1 than 2. This, when combined with the license differences between the two exclusive clusters, suggests that technologies that are licensed to inventor-founded start-ups use more diligence terms and are more likely to require royalty payments.

There are several counter-intuitive findings observations in these findings. First, inventor founded firms are presumed to have strong commercialization incentives, thus we would not expect licenses to require as many diligence clauses mandating technical, market or organizational development milestones. That royalties are more likely in the cluster with more inventor founded start-ups is interesting; royalty payments (particularly running royalties or those tied to milestones, as opposed to annual royalties) align the incentives of the inventor with the licensee, which presumably would not be an issue in inventor-founded firms. Additionally, we might expect venture capital providers to function as external monitors of the commercialization process (e.g., VC funding may substitute for monitoring in the license itself via diligence clauses). In the cluster with the highest incidence of VC funding (Cluster 1), however, we also observe the highest incidence of both royalties and diligence clauses. This suggests that the presence of venture capitalists does not substitute for other monitoring mechanisms specified within the license contract, but rather serves as a complement.

The picture that emerges from this analysis is one where the underlying technology is correlated with the choice of licensee; research tools, software, and medical inventions are more likely to be licensed to established firms, while patented inventions are more likely to be licensed to start-ups in exclusive license deals. Moreover, for inventor-founded start-ups and those backed by venture capital, royalties and extensive diligence clauses are much more likely. Involvement by the inventor and venture capitalists appear to proxy for some unobserved quality of the invention; the presence of both is correlated with the greater the commercialization prospects of the licensed technology.

In this paper we have presented new evidence on the process by which university research is commercialized through licensing. We were able to combine two critical aspects of this undertaking that have been identified in the literature, (a) whether a start-up or a more established firm is best positioned to bring a university invention to the market, and (b) conditional on that firm choice by the licensor, how the different classes of risks these two types of entities pose are managed through the design of the licensing contract. The results of our probit analysis are consistent with some prior findings with regard to the question of whether a start-up or established firm is more likely to be the licensee. Our cluster analysis suggests that licensing provisions are not considered independently, but rather contracts are designed with a "portfolio" of provisions in mind, and that certain provisions are complementary. While largely descriptive, these findings raise questions regarding the ramifications on performance of the dual choice problem faced by the licensor–the type of licensee and the design of the contract. We look forward to exploring the performance implications of these concomitant choices in future research.

Table 1: Exemplary License Terms

License Term	Illustration
Exclusivity	Said license under the Licensed Patents is Exclusive, including the right to sublicense pursuant to Article 13, in the Licensed Field of Use for a term commencing as of the Effective Date and ending upon expiration of the last to expire of Licensed Patent(s). STANFORD agrees that it will not grant further licenses under or to the Technology.
Equity	LICENSEE will issue and convey to STANFORD, as consideration for the granting of the license from STANFORD to LICENSEE, fifty thousand (50,000) shares of Common Stock of LICENSEE, which shares constitute one percent (1%) of the currently outstanding number of shares of capital stock of the LICENSEE within thirty (30) days after the date of this Agreement. During the term of this Agreement, the LICENSEE will grant to STANFORD the same right to participate in future financing, the same registration rights and the same information rights that the Company grants to an investor in a future round of financing.
Royalties	LICENSEE shall pay STANFORD earned royalties on Net Sales as follows: (a) 1.5%of Net Sales of therapeutics; and (b) 1.5% of Net Sales of diagnostics.
Annual Minimum Fees	LICENSEE shall pay to STANFORD the following amounts as annual royalty advances, each November 15 of the years set forth below: Year — Amount of Annual Royalty 2002–2005 — \$10,000 2006–2010 — \$20,000 2011–each year thereafter — \$30,000 Each of the annual royalty advance payments set forth in this Section 6.3 are nonrefundable, but they are fully creditable against earned royalties to the extent provided in Paragraph 6.7.
License Issue Fees	LICENSEE agrees to pay to STANFORD a noncreditable, nonrefundable license issue royalty of Twenty Thousand Dollars (\$20,000).
Progress Milestone Payments	Licensee shall also pay creditable milestone payments as follows: (a) for therapeutics: (i) \$50,000 upon the first to issue of Licensed Patent(s); and, (ii) \$150,000 upon FDA Approval of a Licensed Product. (b) for a diagnostic Licensed Product, \$50,000 upon first commercial sale.
Patent Reimbursement Fees	Within thirty (30) days after receipt of a statement from STANFORD, LICENSEE shall reimburse STANFORD for all reasonable costs incurred and paid by STANFORD after August 1, 2001 in connection with the preparation, filing and prosecution of all patent applications and maintenance of patents within Licensed Patent(s) covering the Invention(s).
Developmental Milestones	As an inducement to STANFORD to enter into this Agreement, LICENSEE agrees to use all reasonable efforts and diligence to proceed with the development, manufacture, and sale or lease of Licensed Products and to diligently develop markets for the Licensed Products, either by itself or through its Affiliates or sublicensees. STANFORD may, at its option, convert all Exclusive licenses granted herein to non-exclusive if LICENSEE fails to meet any of the following diligence milestones (dates are calculated from the Effective Date): (a) within six (6) months, provide STANFORD with a detailed business plan identifying three top target markets and applications, including a research and development funding plan for at least one Licensed Product; (b) within eighteen (18) months, develop prototype specifications and design for at least one Licensed Product; (c) within eighteen (18) months, complete a Successful Financing; (d) within thirty-six (36) months, complete a working prototype of a Licensed Product; and (e) within forty-eight (48) months, make a First Commercial Sale of a Licensed Product.
Progress Reports Required	Progress Report. On or before September I of each year until LICENSEE markets a Licensed Product, LICENSEE shall make a written annual report to STANFORD covering the preceding year ending June 30, regarding the progress of LICENSEE toward commercial sale or use of Licensed Products. Such report shall include, as a minimum, information sufficient to enable STANFORD to satisfy reporting requirements of the U.S. Government and for STANFORD to ascertain progress by LICENSEE toward meeting the technical and financial diligence requirements of this Article 5. These reports are LICENSEE's confidential information under Article 20.

Table 2: Technology, Inventor, Firm, and Industry Characteristics

Variable	**Description**	**Source**
Technology Characteristics		
Software	Invention is software or related to development of an algorithm	Stanford OTL
Medical	Invention is a medical device	Stanford OTL
Consumer	Invention is a consumer product, but not a therapeutic drug	Stanford OTL
Tool	Invention is a research tool used by other researchers	Stanford OTL
Process	invention is a production process	Stanford OTL
Patented	Invention is patented at or near license execution date	Stanford OTL
Federal Funding	Research generating invention was federally funded	Stanford OTL
Inventor Characteristics		
Inventor Department	Whether an inventor was appointed in the following departments: • Computer Science • Chemistry • Genetics • Pathology • Electrical Engineering • Physics (No observations in sample) • Medicine (omitted category) • Non-Stanford Department	Stanford OTL
Mean Number of Prior Inventions	Mean of prior invention disclosures by inventor for current licensed technology	Stanford OTL
Industry Characteristics		
Effectiveness of Appropriability Mechanisms:		
Patents	% of industry respondents claiming patents as an effective appropriability mechanism	CMU Survey
Complementary Sales	% of industry respondents claiming complementary sales as an effective appropriability mechanism	CMU Survey
Complementary Manufacturing	% of industry respondents claiming complementary manufacturing as an effective appropriability mechanism	CMU Survey
Lead time Manufacturing	% of industry respondents claiming lead time as an effective appropriability mechanism	CMU Survey
Industry Concentration	HHI index, scaled (divided by 1000)	US Census of Manufacturers, 1997 and 2002
Firm Characteristics		
Start-Up	Whether firm is a start-up based on founding year	Various
VC Funding	Whether firm has VC funding at license execution date	Stanford OTL
Firm Size	Whether firm is large (greater than 500 employees)	Stanford OTL
Inventor Founded	Whether firm was founded by Stanford inventor	Stanford OTL
Future Variables (Not currently in analysis)		
Drug	Invention is a therapeutic drug	
Prototype Exists	A prototype exists prior to license execution date	Goldfarb and Colvyas Survey
Radical	If innovation is radical—3-digit patent classes in patents cited by focal patent but not directly cited by focal patents	USPTO (patented inventions only)
Invention Scope	Breadth of invention—Number of international classes cited by patent	USPTO (patented inventions only)
Tacit Knowledge	Need for tacit knowledge transfer by inventor	Stanford OTL (license terms on know-how clauses)

Table 3: Invention Characteristics - Full Sample

	(A) Full Sample n=852		(B) Start-Up Firms n=171		(C) Established Firms n=681	
	N	%	N	%	N	%
Invention received federal funding	572	67.1%	106	62.0%	466	68.4%
Consumer product	158	18.5%	43	25.1%	115	16.9%
Production process	54	6.3%	17	9.9%	37	5.4%
Research tool	588	69.0%	95	55.6%	493	72.4%
Therapeutic drug	52	6.1%	16	9.4%	36	5.3%
Software invention	185	21.7%	39	22.8%	146	21.4%
Chemical	14	1.6%	4	2.3%	10	1.5%
Electronic	55	6.5%	15	8.8%	40	5.9%
Optical	60	7.0%	19	11.1%	41	6.0%
Telecom	15	1.8%	9	5.3%	6	0.9%
Other non-medical	43	5.0%	8	4.7%	35	5.1%
Medical invention	570	66.9%	88	51.5%	482	70.8%
Biotech	307	36.0%	47	27.5%	260	38.2%
Medical devices	24	2.8%	8	4.7%	16	2.3%
Pharmaceutical	34	4.0%	5	2.9%	29	4.3%
Other medical	114	13.4%	17	9.9%	97	14.2%
Patent exists	372	43.7%	80	46.8%	292	42.9%
Year of license						
1990-1998	449	52.7%	76	44.4%	373	54.8%
1999-2000	249	29.2%	67	39.2%	182	26.7%
2001-2004	154	18.1%	28	16.4%	126	18.5%

Table 4: Inventor Characteristics - Full Sample

	(A) Full Sample n=852		(B) Start-Up Firms n=171		(C) Established Firms n=681	
	N	%	N	%	N	%
Inventor invented before current invention	495	58.1%	98	57.3%	397	58.3%
Electrical engineering department	139	16.3%	76	44.4%	91	13.4%
Chemistry department	89	10.4%	22	12.9%	67	9.8%
Computer science department	28	3.3%	3	1.8%	25	3.7%
Genetics department	73	8.6%	13	7.6%	60	8.8%
Pathology department	102	12.0%	18	10.5%	84	12.3%
Medicine department (in school of med)	87	10.2%	15	8.8%	72	10.6%
School of medicine	506	59.4%	81	47.4%	425	62.4%
Non-Stanford department	30	3.5%	7	4.1%	23	3.4%

Table 5: Invention Characteristics - Exclusive Subsample

	(A) Full Sample n=383		(B) Start-Up Firms n=98		(C) Established Firms n=255	
	N	%	N	%	N	%
Invention received federal funding	214	60.60%	53	54.10%	161	63.10%
Consumer product	81	22.90%	22	22.40%	59	23.10%
Production process	31	8.80%	12	12.20%	19	7.50%
Research tool	194	55.00%	48	49.00%	146	57.30%
Therapeutic drug	47	13.30%	16	16.30%	31	12.20%
Software invention	53	15.00%	13	13.30%	40	15.70%
Chemical	10	2.80%	2	2.00%	8	3.10%
Electronic	25	7.10%	9	9.20%	16	6.30%
Optical	43	12.20%	14	14.30%	29	11.40%
Telecom	11	3.10%	6	6.10%	5	2.00%
Other non-medical	25	7.10%	6	6.10%	19	7.50%
Medical invention	205	58.10%	53	54.10%	152	59.60%
Biotech	78	22.10%	22	22.40%	56	22.00%
Medical devices	22	6.20%	8	8.20%	14	5.50%
Pharmaceutical	29	8.20%	5	5.10%	24	9.40%
Other medical	56	15.90%	13	13.30%	43	16.90%
Patent exists for invention	209	59.20%	56	57.10%	153	60.00%
Year of license						
1990-1998	187	53.00%	45	45.90%	142	55.70%
1999-2000	107	30.30%	36	36.70%	71	27.80%
2001-2004	59	16.70%	17	17.30%	42	16.50%

Table 6: Inventor Characteristics - Exclusive Subsample

	(A) Full Sample n=383		(B) Start-Up Firms n=98		(C) Established Firms n=255	
	N	%	N	%	N	%
Inventor invented before current invention	180	51.00%	56	57.10%	124	48.60%
Electrical engineering department	75	21.20%	25	25.50%	50	19.60%
Chemistry department	30	8.50%	11	11.20%	19	7.50%
Computer science department	10	2.80%	3	3.10%	7	2.70%
Genetics department	28	7.90%	9	9.20%	19	7.50%
Pathology department	27	7.60%	9	9.20%	18	7.10%
Medicine department (in school of med)	55	15.60%	11	11.20%	44	17.30%
School of medicine	188	53.30%	46	46.90%	142	55.70%
Department outside of Stanford	7	2.00%	1	1.00%	6	2.40%

Table 7: Invention Characteristics - Non-Exclusive Subsample

	(A) Full Sample n=490		(B) Start-Up Firms n=71		(C) Established Firms n=419	
	N	%	N	%	N	%
Invention received federal funding	350	71.40%	51	71.80%	299	71.40%
Consumer product	77	15.70%	21	29.60%	56	13.40%
Production process	23	4.70%	5	7.00%	18	4.30%
Research tool	386	78.80%	45	63.40%	341	81.40%
Therapeutic drug	4	0.80%	0	0.00%	4	1.00%
Software invention	130	26.50%	25	35.20%	105	25.10%
Chemical	4	0.80%	2	2.80%	2	0.50%
Electronic	30	6.10%	6	8.50%	24	5.70%
Optical	16	3.30%	4	5.60%	12	2.90%
Telecom	4	0.80%	3	4.20%	1	0.20%
Other non-medical	18	3.70%	2	2.80%	16	3.80%
Medical invention	358	73.10%	35	49.30%	323	77.10%
Biotech	224	45.70%	25	35.20%	199	47.50%
Medical devices	2	0.40%	0	0.00%	2	0.50%
Pharmaceutical	5	1.00%	0	0.00%	5	1.20%
Other medical	57	11.60%	4	5.60%	53	12.60%
Patent exists for invention	160	32.70%	23	32.40%	137	32.70%
Year of license						
1990-1998	255	52.00%	30	42.30%	225	53.70%
1999-2000	141	28.80%	30	42.30%	111	26.50%
2001-2004	94	19.20%	11	15.50%	83	19.80%

Table 8: Inventor Characteristics - Non-Exclusive Subsample

	(A) Full Sample n=490		(B) Start-Up Firms n=71		(C) Established Firms n=419	
	N	%	N	%	N	%
Inventor invented before current invention	308	62.90%	40	56.30%	268	64.00%
Electrical engineering department	63	12.90%	22	31.00%	41	9.80%
Chemistry department	57	11.60%	10	14.10%	47	11.20%
Computer science department	18	3.70%	0	0.00%	18	4.30%
Genetics department	45	9.20%	4	5.60%	41	9.80%
Pathology department	72	14.70%	9	12.70%	63	15.00%
Medicine department (in school of med)	32	6.50%	4	5.60%	28	6.70%
School of medicine	311	63.50%	35	49.30%	276	65.90%
Department outside of Stanford	21	4.30%	6	8.50%	15	3.60%

Table 9: Licensee Characteristics - Full Sample

	(A) Full Sample n=677		(B) Start-Up Firms n=138		(C) Established Firms n=539	
	N	%	N	%	N	%
Small firm [a] (classifIed by OTL)	336	58.4%	111	84.1%	225	50.8%
Startup firm (classified by OTL)	171	20.1%	171	100.0%	0	0.0%
VC funded	152	17.8%	39	22.8%	113	16.6%
Firm is inventor founded	164	19.2%	81	47.4%	83	12.2%
Firm is software firm	112	13.1%	25	14.6%	87	12.8%
Firm is publishing firm	10	1.2%	1	0.6%	9	1.3%

Note:
[a]OTL observed whether a firm was a "small firm" for only 525 of the 852 observations in the sample.

Table 10: License Characteristics - Full Sample

	(A) Full Sample n=677		(B) Start-Up Firms n=138		(C) Established Firms n=539	
	N	%	N	%	N	%
Exclusive license	353	41.9%	98	58.0%	255	37.8%
License terminated	696	81.7%	145	84.8%	551	80.9%
Royalties exist	321	37.7%	75	43.9%	246	36.1%
Issue fee required	597	70.1%	119	86.2%	478	82.4%
Annual minimum royalties exist	399	46.8%	81	58.7%	318	54.8%
Milestone payments required	142	16.7%	31	22.5%	111	19.1%
Equity in licensee acquired as part of royalties	91	10.7%	44	25.7%	47	6.9%
Patent fees offset against royalties	195	22.9%	51	37.0%	144	24.8%
Diligence clauses						
Reasonable efforts to develop' clause	144	16.9%	51	29.8%	93	13.7%
Progress report required by date	118	13.8%	41	24.0%	77	11.3%
Products avaialable for sale by date	85	10.0%	31	18.1%	54	7.9%
Raise capital by date	17	2.0%	8	4.7%	9	1.3%
Any technical diligence clause (dummy)	145	17.0%	51	29.8%	94	13.8%
Any market diligence clause (dummy)	107	12.6%	39	22.8%	68	10.0%
Any organizational diligence clause (dummy)	147	17.3%	52	30.4%	95	14.0%
Any diligence clause (dummy)	166	19.5%	58	33.9%	107	15.7%

Table 11: Licensee Characteristics - Exclusive Subsample

	(A) Full Sample n=383		(B) Start-Up Firms n=98		(C) Established Firms n=255	
	N	%	N	%	N	%
Small firm [a] (classified by OTL)	177	74.10%	72	84.70%	105	68.20%
Startup firm (classified by OTL)	98	27.80%	98	100.00%	0	0.00%
VC funded	83	23.50%	28	28.60%	55	21.60%
Firm is inventor founded	121	34.30%	57	58.20%	64	25.10%
Firm is software firm	25	7.10%	5	5.10%	20	7.80%
Firm is publishing firm	9	2.50%	1	1.00%	8	3.10%

Note:
[a]OTL observed whether a firm was a "small firm" for only 239 of the 353 observations in the exclusive subsample.

Table 12: License Characteristics - Exclusive Subsample

	(A) Full Sample n=383		(B) Start-Up Firms n=98		(C) Established Firms n=255	
	N	%	N	%	N	%
Exclusive license	353	100.00%	98	100.00%	255	100.00%
License terminated	274	77.60%	92	93.90%	182	71.40%
Royalties exist	174	49.30%	47	48.00%	127	49.80%
Issue fee required	252	83.70%	66	85.70%	186	83.00%
Annual minimum royalties exist	171	56.80%	53	68.80%	118	52.70%
Milestone payments required	99	32.90%	26	33.80%	73	32.60%
Equity in licensee acquired as part of royalties	80	22.70%	36	36.70%	44	17.30%
Patent fees offset against royalties	184	61.10%	48	62.30%	136	60.70%
Diligence clauses						
‘Reasonable efforts to develop’ clause	103	29.20%	37	37.80%	66	25.90%
Progress report required by date	90	25.50%	32	32.70%	58	22.70%
Products availalble for sale by date	69	19.50%	24	24.50%	45	17.60%
Raise capital by date	17	4.80%	8	8.20%	9	3.50%
Any technical diligence clause	104	29.50%	37	37.80%	67	26.30%
Any market diligence clause	87	24.60%	30	30.60%	57	22.40%
Any organizational diligence clause	106	30.00%	38	38.80%	68	26.70%
Any diligence clause	111	31.40%	39	39.80%	72	28.20%

Table 13: Licensee Characteristics - Non-Exclusive Subsample

	(A) Full Sample n=490		(B) Start-Up Firms n=71		(C) Established Firms n=419	
	N	%	N	%	N	%
Small firm [a] (classified by OTL)	157	47.30%	38	82.60%	119	41.60%
Startup firm (classified by OTL)	71	14.50%	71	100.00%	0	0.00%
VC funded	69	14.10%	11	15.50%	58	13.80%
Firm is inventor founded	42	8.60%	23	32.40%	19	4.50%
Firm is software firm	86	17.60%	20	28.20%	66	15.80%
Firm is publishing firm	1	0.20%	0	0.00%	1	0.20%

Note:
[a]OTL observed whether a firm was a "small firm" for only 332 of the 490 observations in the non-exclusive subsample.

Table 14: License Characteristics - Non-Exclusive Subsample

	(A) Full Sample n=490		(B) Start-Up Firms n=71		(C) Established Firms n=419	
	N	%	N	%	N	%
Exclusive license	0	0.00%	0	0.00%	0	0.00%
License terminated	417	85.10%	52	73.20%	365	87.10%
Royalties exist	147	30.00%	28	39.40%	119	28.40%
Issue fee required	345	83.70%	53	86.90%	292	83.20%
Annual minimum royalties exist	228	55.30%	28	45.90%	200	57.00%
Milestone payments required	43	10.40%	5	8.20%	38	10.80%
Equity in licensee acquired as part of royalties	11	2.20%	8	11.30%	3	0.70%
Patent fees offset against royalties	11	2.70%	3	4.90%	8	2.30%
Diligence clauses						
‘Reasonable efforts to develop’ clause	41	8.40%	14	19.70%	27	6.40%
Progress report required by date	28	5.70%	9	12.70%	19	4.50%
Products avaialble for sale by date	16	3.30%	7	9.90%	9	2.10%
Raise capital by date	0	0.00%	0	0.00%	0	0.00%
Any technical diligence clause	41	8.40%	14	19.70%	27	6.40%
Any market diligence clause	20	4.10%	9	12.70%	11	2.60%
Any organizational diligence clause	41	8.40%	14	19.70%	27	6.40%
Any dilgence clause	55	11.20%	20	28.20%	35	8.40%

Table 15: Licensing to Startups or Established Firms? (Full Sample)

	PROBIT Dependent Variable: Start-Up = 1		
	Invention Characteristics (1)	Add Inventor Characteristics (2)	Add Industry Characteristics (3)
Technology Age	0.0104 (0.0168)	0.0139 (0.0174)	0.0092 (0.0190)
Software	-0.0794 (0.1383)	0.0184 (0.1500)	-0.2412 (0.2343)
Medical	-0.5321*** (0.1355)	-0.5048*** (0.1664)	-0.7920*** (0.2376)
Consumer	-0.5694** (0.2478)	-0.5340** (0.2518)	-0.5695** (0.2612)
Tool	-0.6359*** (0.1998)	-0.6576*** (0.2027)	-0.6246*** (0.2075)
Process	-0.3478 (0.2724)	-0.4211 (0.2789)	-0.3438 (0.2893)
Patented	-0.1611 (0.1182)	-0.2033 (0.1236)	-0.179 (0.1307)
Federally funded	-0.0795 (0.1109)	-0.1744 (0.1203)	-0.1227 (0.1221)
Computer science department		-0.7425** (0.3544)	-0.8026** (0.3587)
Chemistry department		0.2101 (0.1716)	0.1998 (0.1857)
Genetics department		0.2657 (0.1976)	0.1656 (0.2026)
Pathology department		0.0404 (0.1918)	0.0322 (0.1985)
Electrical Engineering department		0.3562* (0.1866)	0.2615 (0.2023)
Some inventors outside Stanford		0.2555 (0.2890)	0.3446 (0.2959)
Mean number of prior inventions		-0.0127* (0.0070)	-0.0092 (0.0072)
Inventor team size		0.0964** (0.0390)	0.0942** (0.0398)
Patents effective (CMU)			0.0270** (0.0127)
Complementary sales effective (CMU)			0.0133 (0.0107)
Complementary manufacturing effective (CMU)			-0.0375 (0.0456)
Lead time effective (CMU)			0.0347 (0.0213)
HHI (scaled)			1.6099** (0.6489)
Licensed in 1999-2000			0.2832** (0.1235)
Licensed in 2001-2004			0.0455 (0.1568)
Constant	0.158 (0.2540)	-0.0369 (0.2946)	-2.3654 (2.4803)
N	861	852	852
Log-likelihood	-416.1	-397.8	-390.4
Chi-square	34.55***	58.71***	73.45***
d.o.f.	8	16	23

Standard errors in parentheses.
*** p>0.01 ** p>0.05 * p> 0.10

Table 16: Licensing to Startups or Established Firms? (Exclusive Subsample)

	PROBIT Dependent Variable: Start-Up = 1		
	Invention Characteristics (4)	Add Inventor Characteristics (5)	Add Industry Characteristics (6)
Technology Age	-0.0105 (0.0343)	-0.0201 (0.0356)	-0.035 (0.0402)
Software	-0.1293 (0.2265)	-0.1041 (0.2463)	-0.5021 (0.3173)
Medical	-0.2244 (0.1856)	-0.2254 (0.2326)	-0.1399 (0.3870)
Consumer	-0.4599 (0.2946)	-0.4713 (0.2982)	-0.6981** (0.3246)
Tool	-0.3842* (0.2234)	-0.4026* (0.2278)	-0.4708* (0.2432)
Process	0.0287 (0.3279)	-0.0156 (0.3408)	-0.0315 (0.3587)
Patented	-0.1918 (0.1623)	-0.1916 (0.1663)	-0.1588 (0.1785)
Federally funded	-0.2669* (0.1518)	-0.3712** (0.1625)	-0.3176* (0.1652)
Computer science department		0.2777 (0.4910)	0.2476 (0.5042)
Chemistry department		0.1665 (0.2825)	0.3603 (0.3128)
Genetics department		0.4663 (0.2955)	0.4659 (0.3022)
Pathology department		0.4474 (0.3111)	0.4262 (0.3209)
Electrical Engineering department		0.2729 (0.2698)	0.0014 (0.2991)
Some inventors outside Stanford		-0.5562 (0.6151)	-0.5506 (0.6306)
Mean number of prior inventions		-0.0057 (0.0102)	-0.0003 (0.0108)
Inventor team size		0.0508 (0.0538)	0.0587 (0.0545)
Patents effective (CMU)			-0.0077 (0.0197)
Complementary sales effective (CMU)			0.01 (0.0143)
Complementary manufacturing effective (CMU)			0.0126 (0.0595)
Lead time effective (CMU)			0.0563** (0.0286)
HHI (scaled)			1.4753* (0.8801)
Licensed in 1999-2000			0.1737 (0.1802)
Licensed in 2001-2004			0.1643 (0.2418)
Constant	0.1578 (0.3225)	0.032 (0.3630)	-4.3479 (3.3744)
N	355	353	353
Log-likelihood	-204.3	-200	-195.5
Chi-square	9.725***	17.01***	26.06***
d.o.f.	8	16	23

Standard errors in parentheses.
*** p>0.01 ** p>0.05 * p> 0.10

Table 17: Licensing to Startups or Established Firms? (Non-Exclusive Subsample)

	PROBIT Dependent Variable: Start-Up = 1		
	Invention Characteristics (7)	Add Inventor Characteristics (8)	Add Industry Characteristics (9)
Technology Age	0.0476** (0.0215)	0.0659*** (0.0237)	0.0603** (0.0254)
Software	-0.0762 (0.1880)	0.0289 (0.2219)	0.2969 (0.4453)
Medical	-0.7834*** (0.2075)	-0.7793*** (0.2580)	-1.4416*** (0.3531)
Consumer	0.0396 (0.3625)		
Tool	-0.2321 (0.3349)	-0.4234* (0.2558)	-0.4254 (0.2690)
Process		-0.1066 (0.3927)	0.0506 (0.4343)
Patented	-0.4414** (0.1948)	-0.6603*** (0.2302)	-0.5937** (0.2482)
Federally funded	0.2113 (0.1773)	0.1142 (0.2068)	0.1997 (0.2170)
Computer science department		NA	
Chemistry department		0.3592 (0.2473)	0.3947 (0.2874)
Genetics department		0.048 (0.3121)	-0.1598 (0.3443)
Pathology department		-0.1976 (0.2981)	-0.318 (0.3144)
Electrical Engineering department		0.4870* (0.2819)	0.6584** (0.3289)
Some inventors outside Stanford		0.6723* (0.3581)	0.8299** (0.3792)
Mean number of prior inventions		-0.0183* (0.0107)	-0.0145 (0.0114)
Inventor team size		0.1409** (0.0675)	0.111 (0.0710)
Patents effective raisebox.7ex[0pt](CMU)			0.0623*** (0.0210)
Complementary sales effective (CMU)			0.0018 (0.0200)
Complementary manufacturing effective (CMU)			-0.0823 (0.0854)
Lead time effective (CMU)			-0.0027 (0.0398)
HHI (scaled)			1.7064 (1.1932)
Licensed in 1999-2000			0.5409*** (0.1957)
Licensed in 2001-2004			-0.0241 (0.2420)
Constant	-0.5308 (0.3574)	-0.6224* (0.3552)	0.2396 (4.5812)
N	493	468	468
Log-likelihood	-193	-169.1	-160.6
Chi-square	30.94***	60.26***	77.3***
d.o.f.	7	14	21

Standard errors in parentheses.
*** p>0.01 ** p>0.05 * p> 0.10

Table 18: Cluster Analysis - Invention Characteristics

	(A) Full Sample n=145		(B) Start-Up Firms n=200		(C) Established Firms n=368	
	Mean	Median	Mean	Median	Mean	Median
Technology age	2.700	2.047	2.575	1.921	2.858	2.195
Inventor team size	2.545	2	2.495	2	2.277	2
Mean number of prior inventions	10.000	6	8.730	6	9.178	7
	Frequency	%	Frequency	%	Frequency	%
Invention received federal funding	97	66.9%	115	57.5%	262	71.2%
Consumer product	35	24.1%	47	23.5%	47	12.8%
Production process	17	11.7%	14	7.0%	14	3.8%
Research tool	76	52.4%	112	56.0%	304	82.6%
Therapeutic drug	17	11.7%	27	13.5%	3	0.8%
Software invention	27	18.6%	31	15.5%	101	27.4%
Chemical	3	2.1%	4	2.0%	3	0.8%
Electronic	16	11.0%	10	5.0%	20	5.4%
Optical	20	13.8%	22	11.0%	9	2.4%
Telecom	7	4.8%	4	2.0%	1	0.3%
Other non-medical	10	6.9%	14	7.0%	12	3.3%
Medical invention	70	48.3%	129	64.5%	286	77.7%
Biotech	19	13.1%	55	27.5%	172	46.7%
Medical devices	4	2.8%	14	7.0%	2	0.5%
Pharmaceutical	11	7.6%	16	8.0%	4	1.1%
Other medical	27	18.6%	30	15.0%	44	12.0%
Patent exists for invention	97	66.9%	105	52.5%	82	22.3%
Year of license						
1990-1998	80	55.2%	107	53.5%	180	48.9%
1999-2000	51	35.2%	60	30.0%	108	29.3%
2001-2004	14	9.7%	33	16.5%	80	21.7%

Notes:
Three clusters, based on *k*-means partitioning.
Clusters formed on basis of license characteristics.

Table 19: Cluster Analysis - Inventor Characteristics

	(A) Full Sample n=145		(B) Start-Up Firms n=200		(C) Established Firms n=368	
	Frequency	%	Frequency	%	Frequency	%
Inventor invented before current invention	82	56.6%	108	54.0%	215	58.4%
Electrical engineering department	43	29.7%	32	16.0%	36	9.8%
Chemistry department	20	13.8%	13	6.5%	43	11.7%
Computer science department	6	4.1%	3	1.5%	10	2.7%
Genetics department	10	6.9%	17	8.5%	37	10.1%
Pathology department	6	4.1%	16	8.0%	63	17.1%
Medicine department (in school of med)	16	11.0%	31	15.5%	29	7.9%
School of medicine	62	42.8%	115	57.5%	241	65.5%
Department outside of Stanford	5	3.4%	4	2.0%	18	4.9%

Three clusters, based on *k*-means partitioning.
Clusters formed on basis of license characteristics.

Table 20: Cluster Analysis - Licensee and License Characteristics

	(A) Full Sample n=145		(B) Start-Up Firms n=200		(C) Established Firms n=368	
Licensee Characteristics	Frequency	%	Frequency	%	Frequency	%
Startup firm (classified by OTL)	51	35.2%	42	21.0%	45	12.2%
VC funded	22	15.2%	9	4.5%	4	1.1%
Firm is inventor founded	59	40.7%	52	26.0%	24	6.5%
License Characteristics						
Exclusive license	104	71.7%	197	98.5%	0	0.0%
License terminated	116	80.0%	152	76.0%	313	85.1%
Royalties exist	111	76.6%	95	47.5%	115	31.3%
Issue fee required	130	89.7%	160	80.0%	307	83.4%
Annual minimum royalties exist	119	82.1%	83	41.5%	197	53.5%
Milestone payments required	57	39.3%	53	26.5%	32	8.7%
Equity in licensee acquired as part of royalties	51	35.2%	34	17.0%	6	1.6%
Patent fees offset against royalties	84	57.9%	106	53.0%	5	1.4%
Diligence clauses						
'Reasonable efforts to develop' clause	144	99.3%	0	0.0%	0	0.0%
Progress report required by date	114	78.6%	3	1.5%	1	0.3%
Products available for sale by date	85	58.6%	0	0.0%	0	0.0%
Raise capital by date	16	11.0%	1	0.5%	0	0.0%
Any technical diligence clause	144	99.3%	1	0.5%	0	0.0%
Any market diligence clause	106	73.1%	1	0.5%	0	0.0%
Any organizational diligence clause	145	100.0%	2	1.0%	0	0.0%
Any diligence clause	145	100.0%	7	3.5%	14	3.8%

REFERENCES

Anand, B. N. and Khanna, T. (2000).“The Structure of Licensing Contracts,” *The Journal of Industrial Economics*, **48(1)**: 103–135.

Arora, A., Fosfuri, A., and Gambardella, A. (2001). Markets for Technology: The Economics of Innovation and Corporate Strategy, Cambridge, MA: MIT Press.

Arora, A. (1996). “Contracting for Tacit Knowledge: The Provision of Technical Services in Technology Licensing Contracts,” *The Journal of Development Economics*, **50**: 233–256.

Arrow, K. J. (1962). “Economic welfare and the Allocation of Resources for Invention,” in R. R. Nelson, ed., The Rate and Direction of Inventive Activity, 609–625. (Princeton, NJ: Princeton University Press).

Bousquet, A. H. Cremer, M. Ivaldi, and M. Wolkowicz (2008). “Risk Sharing in Licensing,” *International Journal of Industrial Organization* **16(5)**: 535–554.

Calinski, T. and J. Harabasz (1974). “A Dendrite Method for Cluster Analysis,” *Communications in Statistics* **3**: 1-27.

Dessein, W. (2005). “Information and Control in Ventures and Alliances,” *Journal of Finance* **60(5)**: 2513–2549.

Elfenbein, D. (2004). “Contract Structure and Performance of Technology Transfer Agreements: Evidence from University Licenses,” Working Paper.

Jensen, R. and Thursby M. (2001). “Proofs and Prototypes for Sale: The Licensing of University Inventions,” *American Economic Review*, **91(1)**: 240–259.

Gallini, N. T. and B. D. Wright (1990). “Technology Transfer under Asymmetric Information,” *RAND Journal of Economics* **21(1)**: 147–160.

Ichniowski, C., K. Shaw, and G. Prennushi (1997). “The Effects of Human Resource Management Practices on Productivity: A Study of Steel Finishing Lines," *American Economic Review* **87(3)**: 291-313.

Kamien, M. I. (1992). “Patent Licensing,” Ch. 11 in R. J. Aumann and S. Hart, eds., Handbook of Game Theory, 1.

Kaplan, S. N., and P. Strömberg. 2003. “Financial Contracting Theory Meets the Real World: An Empirical Analysis of Venture Capital Contracts," *Review of Economic Studies* **70**: 281–315.

Leute, K. (2005). “Stanford’s Licensing and Equity Practices with Biotechnology Companies,” *Journal of Commercial Biotechnology* **11(4)**: 318–324.

Lowe, R. A., and A. A. Ziedonis (2006). “Overoptimism and the Performance of Entrepreneurial Firms,” *Management Science* **52(2)**: 173–186.

Mansfield, E., M. Schwartz, and S. Wagner (1981). “Imitation Costs and Patents: An Empirical Study,” *Economic Journal* **91**: 907–918.

Mowery, D. C., R. R. Nelson, B. N. Sampat, and A. A. Ziedonis (2004). Ivory Tower and Industrial Innovation (Palo Alto, CA: Stanford University Press).

Schumpter, J. A. (1942). Capitalism, Socialism, and Democracy New York: Harper).

Shane, S. (2002). “Selling University Technology: Patterns from MIT,” *Management Science* **48(1)**: 122–133.

Shane, S., and A. Nerkar (2003). “When Do Start-ups That Exploit Patented Academic Knowledge Survive?" *International Journal of Industrial Economics* **21(9)**: 1391–1410.

Somaya, D., Y. Kim., and N. S. Vonortas (2011). “Exclusivity in Licensing Alliances: Using Hostages to Support Technology Commercialization,” *Strategic Management Journal* **32(2)**: 159–186.

Thursby, M., J. Thursby, J., and E. Dechenaux (2005). “Shirking, Shelving, and Sharing Risk: The Role of University License Contracts,” NBER Working Paper No. 11128.

Ziedonis, A.A. (2007). “Real Options in Technology Licensing,” *Management Science* **53(10)**: 1618–1633.