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EXCLUSIVITY IN LICENSING ALLIANCES: USING HOSTAGES TO SUPPORT TECHNOLOGY COMMERCIALIZATION

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We examine why exclusivity provisions are used in licensing alliances, and when restrictions in licensing scope (e.g., by product or geography) accompany these exclusivity provisions. We find broad support for the proposition that these features are associated with the contractual challenges of allying with licensees when they contribute valuable complementary capabilities toward the commercialization of licensed technologies. Evidence from our data suggests that exclusivity is used as a contractual hostage to safeguard licensee investments in complementary assets and to enable contracting over early stage technologies. Scope restrictions are employed to balance the tradeoffs between the value creation made possible by licensee complementary capabilities and the transactional hazards entailed in working exclusively with licensees. Our results also suggest that scope restrictions and other formal safeguards may be substitute mechanisms for managing similar transactional concerns in licensing alliances. Copyright © 2010 John Wiley & Sons, Ltd.

INTRODUCTION

Licensing is a phenomenon of vital research interest to the study of interfirm collaboration as well as technology commercialization. A number of studies have established that technology licensing and alliances comprise a large and growing share of interfirm partnering arrangements (Contractor and Lorange, 2002; Hagedoorn, 2002), and play a central role in harnessing the complementary capabilities of partner firms for cooperative technology commercialization (Teece, 1986, 1992; Deeds and Hill, 1996; Rothaermel and Boeker, 2008). Arora, Fosfuri, and Gambardella (2001) estimate over 15,000 technology licensing transactions took place worldwide in the period 1985–1997, with a total value of over $320 billion. These data highlight the importance of licensing as a mechanism for innovators to find markets for their technologies, as a vehicle for knowledge transfer between firms, and as a vital link in the innovation process more broadly (Arora *et al.*, 2001; Link and Scott, 2002). In industries like biotechnology and

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semiconductors, the growth of licensing appears to have even altered fundamental industry structure by fostering vertical disintegration (Merges, 1998; Arora *et al*., 2001; Linden and Somaya, 2003), thus reversing a historical trend toward internalizing research and development (R&D) within firms (Mowery, 1983).

However, the ultimate impacts of licensing relationships are determined by how these agreements are structured and specified. Differently structured technology partnerships can lead to better or worse coordination among partners (Gulati and Singh, 1998; Gulati, Lawrence, and Puranam, 2005), more or less dissemination of knowledge (Link and Scott, 2002), and finally more or less commercial success (Hoetker and Mellewigt, 2009). In licensing agreements, arguably the most important structural choice is whether the license is exclusive or nonexclusive. An exclusive license implies that the licensor agrees to work with only one commercialization partner, thus precluding relationships with other firms. Exclusivity is therefore a strategic choice, ideally designed to ensure the most commercial success for the licensor while accounting for the licensee's incentives to participate productively in the license. Exclusive licenses are also often restricted to specific products[1] or to specific geographic markets (Caves, Crookell, and Killing, 1983; Anand and Khanna, 2000), and these scope restrictions add another interesting dimension to the structure of licensing arrangements. In this paper, we investigate these two related questions: why do firms license technologies exclusively, and when do they employ restrictions to limit the scope of exclusive licenses?

Apart from the implications for technology commercialization, understanding licensing exclusivity (and associated scope restrictions) is also valuable for alliances research, which has been increasingly interested in how interorganizational relationships are structured and governed (Parkhe, 1993; Ring and Van de Ven, 1992; Oxley and Sampson, 2004; Ariño and Reuer, 2006; Hagedoorn and Hessen, 2007; Reuer and Ariño, 2007). The importance of the exclusive licensing decision is recognized by both managers (Chen, 1996; Nickerson, 1996) and policy makers (Ordover, 1991; Jorde and Teece, 1993); however management research in this area has been sparse. Additionally, alliances research in particular, with its focus on cooperative technology commercialization and its understanding of contractual hazards and governance (Hagedoorn, 1990; Gulati, 1995; Dyer, 1997; Oxley, 1997; Ariño and Reuer, 2006), has the potential to add significantly to our understanding of this phenomenon.

While technology licensing has long been modeled in economic theory (e.g., see Katz and Shapiro, 1985; Rockett, 1990), the question of exclusivity in licensing has remained somewhat marginalized. When it has been considered, exclusive licensing has been primarily modeled as an attempt to influence market structure in the downstream product market. For example, some models show that exclusive licensing may be preferred for 'drastic innovations,' which would force all nonlicensees to exit the industry (Kamien and Tauman, 1986; Katz and Shapiro, 1986). Although Oster (1995) showed that this would not be the optimal strategy for licensing a sequence of innovations, the overall logic of increasing downstream profits and thus the extractable surplus also permeates models of exclusive licensing with asymmetric information about the technology (Gallini and Wright; 1990) and asymmetric ability among licensees (Yi, 1998). Similarly, Arora and Fosfuri (2003) and Kim and Vonortas (2006) describe models in which innovators, who are also producers, license to fewer firms (in the limit, exclusively) in highly differentiated markets to limit direct product market competition among licensees (and with the licensor). A secondary driver of exclusive licensing in economic models is the strength of the appropriability regime protecting the technology, but the conclusions here are mixed. In Gallini and Wright's (1990) model, nonexclusive licensing reduces the licensee's incentives to incur the fixed costs of circumventing the technology, so nonexclusive licenses are favored when appropriability is weak. However, other models suggest that weak appropriability may lead to more exclusive licensing due to higher transaction costs (Arora and Fosfuri, 2003) and leakage in the transfer of rents to licensors (Kim and Vonortas, 2006).

In essence, this stream of theorizing in economics reflects an archetype of licensing as an arms-length intellectual property (IP) transaction that simply leverages the presumed market power

[1] The term of art is typically 'field-of-use,' which can include products and/or applications (e.g., for process technologies). From here on we simply use 'product scope' for this type of scope restriction.

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of the licensor's innovation in the product market. While the commercialization abilities of the licensee are implicitly acknowledged as a reason to license, formal models of exclusive licensing generally overlook the challenges of inducing licensees to contribute these valuable capabilities.[2] This neglect of complementary assets is glaring because managers and technology commercialization professionals invariably cite access to complementary capabilities as a primary driver of licensing. Consider the following illustrative quotes relating to licenses in our sample:

> *'We believe that teaming up with Amgen and Kirin, which both have a great deal of experience in the area of oncology is the best and fastest way to develop and get TPO [thrombopoietin] on the market and to ensure a strong competitive position' (Bruce Carter, corporate executive vice president and chief science officer of Novo Nordisk).*[3]
>
> *'We view it [IGEN's license to Boehringer Mannheim] as a model of a successful working relationship between a small, high technology company and a large, transnational enterprise with its marketing and manufacturing capability' (Dr. Richard Massey, president and chief operating officer of IGEN).*[4]

In each of these examples, the motivation for licensing is quite clearly to tie up with a company that can contribute valuable complementary assets. Moreover, managers often attribute the use of exclusive licensing to accessing complementary capabilities. As one academic inventor and entrepreneur we interviewed explained: 'If we didn't give them an exclusive license, they would not want to work with us. What would protect them after they have helped to develop our technology?' At the same time, committing to work exclusively with just one commercialization partner exposes the licensor firm to significant risks. For example, the licensee may devote inadequate complementary resources, or learn from the licensor and then commercialize its own technology, or its priorities may change over time, or it may simply be less capable than initially thought. In essence, these concerns highlight the critical 'alliance' dimension of licensing, wherein the need for inducing bilateral cooperation between the parties in the face of potential hazards is a central challenge.

Adopting such an alliance lens, we focus our investigation on licenses through which licensors access the complementary capabilities of licensee firms for commercializing their technology.[5] In these cooperative arrangements, licensees may experience transactional hazards due to the uncertainties associated with early stage technologies or if they are required to make technology-specific complementary investments. Our main proposition is that by licensing a technology exclusively, the licensor provides a contractual hostage (Williamson, 1983; Deeds and Hill, 1999; Chen and Hennart, 2004; Ahmadjian and Oxley, 2006), which induces capable licensees to participate in and contribute toward technology commercialization even in the face of these transactional hazards. Furthermore, drawing on prior work about the scope of alliances (Khanna, 1998; Oxley and Sampson, 2004), we explain that (product and geographic) restrictions in licensing scope may be used to mitigate some of the hazards that exclusivity in turn creates for licensors. Our empirical analyses are conducted on a broad dataset of

[2] There are a number of other differences between economic models of exclusive licensing and our approach in this paper. For example, virtually all prior models focus on a cost reducing process technology that is licensed to firms producing a homogeneous product, and treat an exclusive license as simply the lower bound (= 1) of the number of potential licensees. By contrast, we view exclusive licensing as a credible commitment to work with a single partner, and our focus is on licensing for commercialization, which often entails product technologies. By commercialization, we mean all the complementary activities that may lead to the ultimate market success of the (licensed) technology. In our empirical analyses, we focus on downstream R&D, manufacturing, and marketing, which are arguably the most common (and important) components of commercialization.

[3] 'Novo Nordisk signs license agreement with Amgen and Kirin on thrombopoietin,' *Business Wire*, 15 August, 1995, Copenhagen, Denmark.

[4] 'IGEN ORIGEN Technology to be Used in New Boehringer Mannheim Clinical Instruments,' *Business Wire*, 20 July, 1995, Gaithersburg, Maryland.

[5] In practice, such licenses often entail technology transfer from innovative start-ups to established firms, but not exclusively so; sometimes, even established firms may lack complementary capabilities in certain markets or for some new technologies they have developed. The licensed technologies are also typically commercializable as a separate product or offering, unlike 'component' technologies that may comprise a small and integral part of a much larger multi-invention product. Generally product technologies tend to be licensed for access to complementary capabilities, but our data also include process technologies that are enabling or targeted solutions for the manufacture of particular products. Importantly, we exclude from our analysis licenses designed purely to settle patent disputes, or avoid them (e.g., cross-licensing), as well as licenses with affiliated firms (such as subsidiaries or joint ventures).

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licensing alliances in the chemicals, pharmaceuticals, and biotechnology industries.

Overall, our study advances the licensing literature by investigating a novel explanation for exclusivity provisions; namely, as contractual solutions to the transactional hazards between technology-providing licensors and complementary asset-providing licensees. We also undertake the first focused and fine-grained empirical investigation of exclusive licensing, thus going beyond earlier broad studies of licensing agreements (Anand and Khanna, 2000; Kim and Vonortas, 2006). In addition, we provide and test explanations for scope restrictions in licensing, which have received virtually no attention in prior scholarly work. Simultaneously, we contribute to the literature on alliances by developing a detailed understanding of an important structural feature of licensing alliances; namely, exclusivity. In addition to the specifics of such structural features, alliances research has developed an increasing interest in how different types of alliance governance are interrelated (Poppo and Zenger, 2002; Hoetkar and Mellewigt, 2006; Ryall and Sampson, 2009). We hypothesize and find support for substitution between product scope restrictions in licensing and other formal relationships between the alliance partners, thus adding to this burgeoning research area. Finally, because this paper explores the challenges and mechanisms entailed in combining complementary resources and technologies across firm boundaries, it is also relevant for our broader understanding of the dynamic sources of firm competitive advantage (Teece, 1986; Teece, Pisano, and Shuen, 1997).

THEORY AND HYPOTHESES

In principle, licensing offers the advantage of employing valuable complementary assets owned by another firm in the commercialization of a firm's technology (Teece, 1986; Arora and Ceccagnoli, 2006), and may therefore increase the chances of its eventual success. However, contracting over technology in this way involves risks for both partners. First, the licensor effectively loses control of the technology and becomes largely dependent on its partner(s) for commercial success. In addition to risks arising from incomplete knowledge about the licensee's capabilities and priorities, licensing alliances expose the licensor to a number of appropriability hazards (see e.g., Oxley, 1997). At the same time, the licensee also faces concerns about whether it will be able to obtain adequate returns for its valuable complementary assets when these are deployed in the service of a licensor's technology. Because technology and complementary capabilities can both be translated into rents by alternative means, either internally or in concert with other partners, addressing these concerns is important for the success of licensing strategies.

In response to these issues, the structure of licensing contracts can play a valuable role by balancing relative contributions and risks of the parties and providing appropriate mechanisms for aligning their relationship. Exclusivity in particular can function as a commitment mechanism by providing a hostage (Williamson, 1983), which limits the licensor's *ex post* options and shields the licensee from opportunistic behavior. Some studies have equated exclusive licensing with licensing to one partner versus many (Arora and Fosfuri, 2003; Kim and Vonortas, 2006), but this view is inconsistent with recent empirical findings that many technologies are licensed nonexclusively *and* to only one firm (Pressman *et al*., 2006). To be accurate, therefore, an exclusive license should be understood as the licensor surrendering its *option* to license to additional parties, which we describe as a hostage held by the licensee.

Providing such a hostage entails some risks for the licensor because it limits the licensor's options if the licensee does not perform, for example, because the licensee was less capable than initially thought, or it devoted inadequate resources for commercialization, or its priorities changed over time. Committing to an exclusive license also creates room for licensee opportunistic behavior (Williamson, 1983, 1985); for example, by learning from the licensor and subsequently commercializing its own technology. While the licensor may try to limit these risks by including specific targets and benchmarks in the licensing contract, contracting over technology in this way entails significant uncertainties. For example, the technology may evolve in unexpected ways or the key performance metrics of the product may change, making prespecified targets and benchmarks less relevant. In essence, technology licensing contracts are inherently incomplete and may leave the licensor exposed to hazards arising from unforeseen contingencies (Aghion and Tirole, 1994). Retaining the option to license to additional parties can alleviate

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these concerns by serving as a broad policing and remedial device against licensee nonperformance. Ultimately, therefore, the exclusive licensing decision reflects trade-offs between the value to the licensor of retaining this option versus the benefits of licensee participation and cooperation that are induced by offering exclusivity as a hostage.

Drawing on these ideas, we first present theoretical motivations for engaging in exclusive licensing, and then develop more nuanced arguments about the use of (product and geographic) scope restrictions in exclusive licenses. This two-step exposition has the advantage of focusing on the transactional hazards faced by the licensee first, and the licensor next, in stages. Moreover, it helps us understand the general motivations for exclusive licensing, before addressing the reasons to use scope restrictions in these licenses. However, we do not mean to imply that the decision making by firms is nested in two stages. In Figure 1, we present our proposed licensing decision-tree, which illustrates that firms simultaneously make trade-offs among four alternatives—nonexclusive licensing, unrestricted exclusive licensing, exclusive licensing with product restrictions, and exclusive licensing with geographic restrictions. These decisions are made by considering both licensee and licensor transactional concerns simultaneously, and balancing the trade-offs between them. Theoretically, our nonnested decision model is logical because firms are likely to consider nonexclusive licensing and scope restrictions as direct alternatives since both approaches can address licensor concerns about (unrestricted) exclusive licensing. Moreover, as we note below (see 'Data and Methods'), specification tests also indicate no empirical support for a nested decision model in our data.

Figure 1. Theorized model of decision making about exclusive licensing

Complementary asset investments

Beginning with Teece (1986), a sizable literature has explored the role of complementary assets in firms, both as a source of value and as a barrier to imitation. Complementary assets, when not generic, are known to be useful for appropriating returns to innovation (Cohen, Nelson, and Walsh, 2000), for profiting from alliances (Rothaermel, 2001), and for weathering the effects of radical or disruptive technological change (Tripsas, 1997; Rothaermel and Hill, 2005). Barriers to the imitation of complementary assets may arise due to a number of factors, such as their embodiment in tacit routines (Nelson and Winter, 1982), time compression diseconomies in imitation (Dierickx and Cool, 1989), or the sheer complexity of the organizational interconnections that make up such a capability (Rivkin, 2000). In sum, complementary assets can be both valuable and difficult to imitate, so that their owners would likely have multiple rent-creation opportunities stemming from them. Therefore, licensors wishing to attract strong commercialization partners must make it appealing for these potential licensees to contribute their complementary capabilities.

Frequently, the complementary capabilities owned by potential licensees are upstream and abstract, which must be translated into specific downstream assets in order to successfully commercialize a technology. For example, broad marketing-related capabilities may need to be translated into marketing programs, advertising investments, regulatory approvals, sales training, and distribution networks. Similarly, manufacturing capabilities must often be translated into dedicated production facilities, and R&D abilities into complementary R&D programs and investments. Moreover, these downstream complementary assets may need to be developed in highly technology-specific ways to effectively harness the commercial prospects of the licensed technology. Even when their upstream capabilities are specialized to a particular area, licensees may need to make further investments that are specific to the licensor's technology. For example, advertising and regulatory programs are often quite specific to the focal product, and complementary R&D investments are generally tied to the focal technology. Simply put, the potential value from combining complementary capabilities with new technologies is often only unlocked when these capabilities are

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translated into technology-specific complementary assets (Teece, 1986).

However, making such complementary investments exposes licensees to significant transactional hazards because they enable subsequent opportunistic actions by licensors. After the licensee invests, the licensor could potentially change its priorities, seek to renegotiate the contract, or expand its choice of partners, leaving the licensee stranded with technology-specific investments that have limited alternate uses (Hart and Moore, 1988). Two critical issues underpin the licensee's dilemma. First, the licensee's development of the licensor's technology changes the licensor's options and incentives over time. For example, a better developed technology may attract more licensing partners, including some who may be more capable than the original licensee. Second, because new technologies entail inherent uncertainties that make licensing contracts substantially incomplete (Aghion and Tirole, 1994), contractual clauses that seek to safeguard against licensor opportunism are unlikely to cover all contingencies that may arise during the course of technology commercialization. The problem is not unlike that of relational contracting, where suppliers that make buyer-specific investments expose themselves to the risk of *ex post* expropriation (Joskow, 1985, 1987; Williamson, 1985). In the licensing context, this risk is exacerbated by the level of uncertainty as well as the licensor's option to license the same technology to additional firms. Under these circumstances, a firm with valuable complementary capabilities would be unlikely to take a license, and even if it did, it would underinvest in the technology-specific resources needed for commercialization.

Exclusive licensing may act as a credible restraint on the licensor's *ex post* behavior by essentially providing the licensee with a hostage. Prior management research on hostages is limited, and has primarily studied the use of equity investments to support various exchange relationships (Deeds and Hill, 1999; Chen and Hennart, 2004; Ahmadjian and Oxley, 2006). Exclusivity appears to be a particularly attractive hostage in licensing contracts due to its significant 'ugly princess' attributes (Williamson, 1983: 526–527). To wit, because of its value to the licensor, licensor opportunism is deterred, but because this value can only be accessed by successful commercialization, it encourages licensee contractual performance as well. In other words, exclusive licensing contracts have significant self-enforcing properties (Tesler, 1980). As Williamson (1983: 521) notes, the effective use of hostages 'can have both *ex ante* (screening) and *ex post* (bonding) effects.' Therefore, when technology-specific investments are needed, licensees with valuable complementary capabilities are more likely to take a license if it is exclusive (the 'screening' effect), and licensees are also likely to make more optimal levels of specific complementary investments under an exclusive license (the 'bonding' effect).

We conclude that exclusivity may facilitate licensing alliances by inducing licensees to contribute their valuable capabilities and to translate them into technology-specific complementary resources. By corollary, when such technology-specific investments are not needed to exploit the value creation possibilities in the alliance, nonexclusive licensing may be used whereby the licensor retains the option of licensing to others. Following this economizing logic (Williamson, 1991),[6] we expect to observe exclusivity in licenses for which technology-specific complementary asset investments are required.

> *Hypothesis 1: Firms will be more likely to engage in exclusive (versus nonexclusive) licensing when the licensee is required to make investments in technology-specific complementary assets.*

Early stage licensing

Some technologies are licensed at an embryonic stage when the potential applications or likely success of the technology are more uncertain. These

[6] In the governance literature generally, and as applied to alliances in particular, the focus is fundamentally on effective coordination as the key driver of organizational arrangements. The logic underlying this approach is that superior coordination creates a surplus (relative to less efficient arrangements) that can be shared between the parties; therefore, effective organizational arrangements are more likely to be chosen and financial terms adapted to make them feasible. As Williamson (1991: 75) put it, 'between economizing and strategizing, economizing is much the more fundamental.' Thus, governance-based theorizing focuses on the effectiveness of organizational arrangements (economizing), and the specific financial terms are assumed to follow from this first-order choice. So, for example, an exclusive licensee may 'compensate' the licensor through more generous financial terms than if the license were nonexclusive, but this arrangement is only preferred (and a high enough compensation only feasible) if the forsaken option of licensing to additional firms creates less value than the added benefits of inducing licensee cooperation through exclusivity.

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early stage licenses,[7] also called *ex ante* licenses in prior work (Anand and Khanna, 2000), present a further set of problems for the parties engaging in licensing. Because early stage technologies entail greater uncertainties, this will exacerbate the transactional concerns licensees have about committing toward the licensor's technology. At a minimum, the perceived risk will be higher in early stage licensing, which will decrease the willingness of licensees to participate in nonexclusive licenses. In addition, there is also a long tradition linking uncertainty with the potential for opportunism and contractual hazards in transactions (Williamson, 1985). The uncertainty inherent in early stage licenses makes it more difficult to fully contract for potential contingencies that may come up at a later stage, thus exposing the licensee to more licensor opportunism down the road.

Early stage technologies pose additional challenges for licensing because they may depend to a greater extent on *ex post* support and cooperation from the licensor for commercial success (Jensen and Thursby, 2001). Knowledge about these embryonic technologies is typically more tacit and complex, and is therefore not easily transferred to the licensee. Moreover, because they are underdeveloped, early stage technologies need more experimentation and tinkering, which licensees would be hard-pressed to do without significant help from the licensor. Citing these concerns for university inventions, which are often early stage, Jensen and Thursby (2001) show in an agency model that patent rights may be essential to foster commercialization. While it does not theorize specifically about exclusivity terms, Jensen and Thursby's model shows that licensors are more likely to support commercialization when their profits are hostage to the eventual commercial success of the technology, which is consistent with our own arguments about the nature of exclusivity provisions. Therefore, as a result of contractual hazards arising from higher uncertainty and a greater need for licensor support in commercialization, we conclude that early stage licensing may also be associated with exclusive licensing.

Hypothesis 2: Firms will be more likely to engage in exclusive (versus nonexclusive) licensing in early stage licenses.

Exclusivity and scope restrictions

While exclusivity may address the concerns of the licensee by serving as a contractual hostage, it also leaves the licensor exposed to many potential risks. Fundamentally, these hazards stem from the incomplete nature of the licensing contract and the licensor's inability to fully monitor the licensee. Williamson (1983) notes that incomplete contracting and barriers to monitoring are important sources of exposure for hostage givers in interorganizational relationships. For example, there are often uncertainties about the evolution of markets and technologies that cannot be adequately specified in licensing contracts, and *ex post* it is often difficult to ascertain how much effort and investment has actually been expended by the licensee to commercialize the technology. Licensors are unable to fully ensure that their licensees will pursue commercialization diligently or that they will refrain from expropriating the technology in subtle ways (e.g., by developing substitutes). While performance targets in the licensing contract can help, these are unlikely to fully account for inherently difficult-to-contract contingencies. In effect, exclusive licensing shifts the burden of transactional hazards onto licensors, and provides room for opportunistic behavior by licensees.

Limiting the scope of licensing contracts may help mitigate these concerns while retaining the attractive hostage exchange properties of exclusivity. In research on internet portal contracts, Elfenbein and Lerner (2009) find that allocation of contingent control rights address similar concerns about exclusivity. Below, we examine two broad contexts in which the scope of exclusive licenses may be restricted. First, when the licensor's hazards are especially high, (product) scope restrictions may help to limit exposure to these hazards. And second, where the value creation opportunities from licensee complementary assets are themselves limited in (geographic) scope, geographic scope restrictions can better calibrate the hazards licensors remain exposed to relative to the

[7] From the perspective of licensees, early stage licenses may be viewed as a type of exploration alliance (Rothaermel and Deeds, 2004: 209), which licensees enter 'to discover something new jointly with an alliance partner.' Indeed our measure of this variable is similar, though not identical, to the one adopted by Rothaermel and Deeds. However, our interest is in licensing structure rather than knowledge development, and in understanding the contractual implications of transacting over inchoate and uncertain early stage technologies in particular.

potential benefits from licensing. In our description below, we clarify that these two motivations for scope restriction are similar. In both cases, the objective would be to calibrate the scope of the license so as to balance the value creation made possible by licensee complementary capabilities against the hazards and risks entailed in transacting for them through exclusive licensing. In essence, the scope of the alliance would be expanded to the point where the *marginal* increase in value creation possibilities just offsets the *marginal* increase in transaction hazards.

Product scope restrictions

Based on the preceding logic, we revisit the implications of early stage technologies for licensing. While exclusivity may address licensee concerns by providing a credible commitment from the licensor, the transactional uncertainties that accompany early stage licensing are also problematic for licensors. In this context, awarding exclusive rights to a single licensee may expose the licensor to significant contractual hazards. When the potential applications of the technology are unclear and uncertain, there are practical limits to the precision with which contractual provisions and safeguards can be written and enforced (Williamson, 1985). At earlier stages, resource contributions and commercialization milestones expected from the licensee are also more likely to be intangible and qualitative, which add to the challenges of measuring and monitoring contractual performance. While agreeing on a valuation for technology is often difficult (Merges, 1994; Merges and Nelson, 1994), it is likely to be particularly challenging in early stage licensing because the technology's potential uses and value to consumers are more uncertain. Apart from being an impediment to licensing by itself, uncertainty in valuation can also reduce the effectiveness of hostage exchange as a credible commitment mechanism (Williamson, 1983). Moreover, if early stage licenses are entered into for purposes of knowledge exploration by the licensee (Rothaermel and Deeds, 2004), they may also entail appropriability hazards (Oxley, 1997) whereby the licensor may risk losing a significant source of competitive advantage. Overall, while exclusive licensing may mitigate many licensee concerns about early stage licensing, it may actually accentuate many of the corresponding risks faced by licensors, or at the very least leave them unaddressed.

These licensor hazards can potentially be addressed by limiting the scope of exclusive licenses and, in particular, by restricting the license to particular products. In prior research, Oxley and Sampson (2004) proposed that firms may limit the scope of technology alliances in order to manage transactional hazards that are very high, which parallels our concerns with early stage licenses. However, extant explanations must be extended to clarify why limiting licensing (or alliance) scope addresses this problem. An important issue is whether by limiting the scope of an alliance or license, the parties are also limiting the potential value that can be unlocked from combinations of their complementary resources. If both (potential) value creation and transaction hazards are affected in the same proportion by narrowing the scope of a license, this will not result in a more effective interorganizational arrangement.

The critical reason why scope limitation may work in practice, though, is that all potential domains of a license (e.g., different product applications) or alliance may not impact transactional concerns and potential value creation proportionally. For example, consider the case of an early stage technology that has many potential commercial uses, including one application that is relatively more evident and well understood, and others that are more distant, untested, and even unknown. As a result, contracting over the first product application is likely to be more complete and easier to monitor, and therefore entail fewer transactional hazards. Moreover, simply because this first targeted use of the technology is better known, it does not follow that it is of lesser value than other potential applications. Therefore, a motivation for narrowing the scope of the license to this initial product is that it will reduce the contractual challenges of transacting for the technology but will not *proportionately* reduce the value creation possibilities in the alliance.[8] If this precondition is met, the narrowing of product scope can be an effective solution to licensor concerns about entering into an exclusive relationship with

[8] What is important here is that among the set of potential product uses of the technology, transactional hazards and value creation possibilities not be *perfectly* correlated. If this condition is met, which is quite likely in the real world variety of potential uses of a technology, there will likely be at least one narrow product (or set of products) with a superior trade-off between value and hazards than the unbounded set of product uses for the technology as a whole.

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a single licensee. Moreover, narrowing the scope of licensing to one or more product applications that are well understood may also reduce potential disagreements about the value of the license, and facilitate such alliances. In summary, product scope restrictions mitigate concerns arising from a key source of uncertainty in early stage licensing; namely, the poorly understood and unknown potential applications of an embryonic technology. Therefore, they are more likely to be used in conjunction with exclusive licensing for early stage technologies.

Hypothesis 3: Firms will be more likely to use exclusive licenses restricted by product scope (over other licensing types) when licensing early stage technologies.

While restricting early stage licenses by product scope may address licensor contractual concerns, it may not be the only means of doing so. Licensing alliances may be accompanied by equity (or other) investments in the licensor or by parallel agreements to purchase (intermediate) products or technologies, which can also serve similar purposes. When hostage givers face potential risks of malfeasance by hostage takers, which is the essential problem faced by early stage licensors, Williamson (1983) highlights mutual hostage exchange and reciprocal trading as potential solutions because both serve as credible relational commitments. In addition to its well-known ability to provide hierarchical governance (Williamson, 1985; Gulati, 1995; Oxley, 1997; Pisano, 1989), equity can also serve as a hostage by giving the equity holder a stake in the success of the firm (Deeds and Hill, 1999; Chen and Hennart, 2004) and acting as a costly signal to other market players (Ahmadjian and Oxley, 2006). Similarly, reciprocal trading arrangements can increase licensees' dependence on licensors for future success and help mitigate the hazards of exclusive early stage licensing, thus making it unnecessary to use product scope restrictions. Prior research also finds that alliances with broader scope are more likely to incorporate stronger governance through equity (Pisano, 1989; Oxley, 1997; Oxley and Sampson, 2004), which suggests that equity and scope limitations may be used in different situations to address similar concerns. Because both equity and reciprocal trading safeguard the licensor similarly by providing credible commitments from the licensee, we group them together but note the differences between their effects in our empirical analyses. Therefore, in sum, we would expect product scope restrictions with exclusive early stage licensing absent other formal relationships like equity investment or reciprocal trading, and no scope restrictions when such relationships are present.

Hypothesis 4: Firms licensing early stage technologies will be more likely to use exclusive licenses without restrictions (in lieu of product restrictions) when other relationships like licensee equity investment or reciprocal trading are present (relative to when they are absent).

Geographic scope restrictions

We approach the use of geographic restrictions in technology licenses with a similar lens as product restrictions; however, in contrast to our arguments above, our main focus here is on the potentially limited scope for value creation of some licensee complementary assets rather than the additional transactional hazards entailed in licensing some types of technologies. Geographic scope restrictions may be used when the transactional concerns of the licensor (when granting exclusivity) span a much broader (geographic) domain than the limited (geographic) scope of capabilities contributed by the licensee. Therefore, by limiting the geographic scope of the license, a significant portion of the value creation possibilities from licensee complementary capabilities will be captured while simultaneously excluding licensor contractual risks relating to domains where these complementary capabilities are weak or nonexistent.

To develop the empirical implications of our logic about geographic scope restrictions, we examine two situations in which the potential value of licensee capabilities is likely to be limited in geographic scope. Often, potential licensees have complementary capabilities that are stronger in some geographic markets than others. This is particularly true in the international context, where many nationally or regionally based firms have superior commercialization capabilities in their domestic or regional markets, but are not as capable globally. In these cases, it would make little sense for a licensor to enter into a worldwide exclusive license and take on the potential risks of licensee nonperformance on a global basis when the primary potential for value creation is

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through complementary assets in specific regional or national markets. The licensor may even have some commercialization capabilities in its domestic market, and be interested in an international partner essentially for its capabilities in foreign markets.

Similarly, we note that complementary marketing capabilities and the technology-specific investments made to translate them into valuable resources for commercialization are often geographically limited in scope. For example, marketing or advertising programs, sales forces, and distribution networks are often limited by national or regional boundaries due to cultural, institutional, and political forces. This is not necessarily true of other complementary resources—investments in R&D, for example, can typically be built on and reused in multiple markets across the globe. Therefore, limiting the geographic scope of licenses that require specific R&D investments is likely to result in suboptimal levels of such investments. By contrast, because purely marketing-related resources are more likely to be limited in geographic scope, limiting the scope of licensing by geography (while also providing exclusivity) will not carry as significant a penalty (as say R&D) in the incentives faced by licensees to participate and invest in such complementary assets. Therefore, because the value creation potential of complementary capabilities is likely to be geographically limited in international licenses and in licenses requiring marketing-only complementary investments, we hypothesize:

Hypothesis 5a: Firms will be more likely to use exclusive licenses restricted by geography (over other licensing types) in licenses that require technology-specific, marketing-only investments.

Hypothesis 5b: Firms will be more likely to use exclusive licenses restricted by geography (over other licensing types) in international licenses (where the licensee is based in a foreign country).

DATA AND METHODS

We use secondary data from Thompson Financial's SDC database to construct a sample of 327 licensing arrangements from 1990–1999, with the criteria being: (i) the licensing is between two firms, where the licensee and licensor are clearly identifiable, (ii) both firms are publicly listed (to facilitate collection of financial data), and (iii) the licensed technologies are in Standard Industrial Classification (SIC) codes 28 and 87. This broad industry category covers chemicals, pharmaceuticals, and biotechnology, which are known to have a higher incidence of exclusive licensing (Anand and Khanna, 2000; Kim and Vonortas, 2006), and therefore makes a good setting for our study.[9] We used SDC because we were interested in studying licensing by different types of firms across a broad industry sector, which SDC data is particularly well suited for (Schilling, 2009). While the database has some drawbacks, these are primarily related to a lack of comprehensive coverage, which is not an inherent drawback for our research question, and missing/poor coding in some fields, which we address significantly by collecting and coding detailed press reports about each license. Finally, we note that even for a set of potentially problematic research questions Schilling (2009) finds that in most cases the results are similar across different alliance datasets.

We obtained press reports for the licensing alliances from a variety of databases including Lexis-Nexis, Factiva, ABI Inform, Business Source Premier, PRNewswire, Mergent Online and Hoover's Online. We examined these news reports to ensure that each license was for the commercialization of technology and actually matched our sampling criteria. On closer examination, 59 observations turned out to be about cross-licensing, outright sales of a business, brand name licensing, patent litigation settlements, license terminations, or even licenses in other industries. After excluding these observations (and three others for which there was very poor news coverage), we were left with a sample of 265 licenses, which are used in our analyses. No financial data were available for neither the licensee nor the licensor in 33 cases (typically in pre-initial public offering [IPO] years), leaving 232 observations for our statistical models (which are nonlinear and cannot accommodate missing data).

[9] A small number of licenses from SIC 87 ('research services') did not involve biotechnology, chemicals, or pharmaceutical technologies and were excluded from the sample to minimize unwarranted heterogeneity.

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Variables

All dependent variables in our analyses are indicator variables. In our initial models that examine simply the likelihood of exclusive licensing, we use the dummy dependent variable *exclusive licensing* (= 1 if the license is exclusive; = 0 if nonexclusive). As noted earlier, focusing first on the motivations for exclusivity broadly helps to systematically advance our rationale. However, firms are in practice choosing simultaneously between a range of licensing choices, including nonexclusive licensing and exclusive licensing with and without scope restrictions. Therefore, in the next step we employ indicator variables for four distinct types of licenses: nonexclusive licenses, worldwide exclusive licenses (with no restrictions), exclusive licenses with product scope restrictions, and exclusive licenses with geographic scope restrictions (always by country or region).[10] The variables are coded from details about the licensing alliance disclosed in press reports, as are a number of the other variables below. Anand and Khanna (2000) also adopt a similar coding strategy for licensing-related variables; but we are able to delve deeper into some licensing features due to the more focused nature of this study. We employed two coders whose coding agreed approximately 82 percent of the time. We exercised our judgment (and examined more news reports and Securities and Exchange Commission disclosures, where needed) in the remaining cases. We also found that we obtained very similar empirical results irrespective of which coding schema was used.

We carefully examined the news articles on each license to code the dummy independent variable *any investment* (= 1 if the license required investments in any complementary assets by the licensee). These investments were further broken down into three types, and coded with dummy variables as follows: *R&D investment, manufacturing investment*, and *marketing investment*. We categorized investments as R&D if the licensee was expected to undertake R&D activities to complement, evaluate, or otherwise develop the licensed technologies. For example, one news article in our data reported: 'Monsanto will form a wholly-owned subsidiary in Cambridge, Massachusetts...Millennium will collaborate with the subsidiary ... Monsanto will fund the new subsidiary's research activities, including staffing...'[11] which was coded = 1 for both *any investment* and *R&D investment* (also = 1 for exclusive licensing). Manufacturing investments usually related to building a plant, modifying existing production facilities, or developing production technologies relating to the licensed technology. Marketing investments related to obtaining regulatory and market clearances, as well as advertising, sales, or distribution for products developed from the technology. While all of these investments were a part of the license and therefore specific to the technology in a broad sense, it is impossible to determine precisely how technology-specific they are. However, investments in the three functional areas may vary systematically in their level of specificity to licensed technologies. The investments in R&D and marketing noted above are largely in intangibles, which are inherently quite technology-specific. Manufacturing investments, by contrast, are mostly in tangible capital goods, which are arguably more redeployable despite being somewhat dedicated at the time of investment (Williamson, 1985). Consequently, we may expect some differences in the relationship between exclusive licensing and licensee investments across these functional areas.

We coded a dummy variable *early stage licensing* (= 1 if the licensed technology was early stage, = 0 otherwise), where an early stage technology is defined as one for which no proof of concept or prototype existed at the time of licensing. For therapeutic drugs, licensing before the second phase of clinical trials was coded as early stage. We expect early stage licensing to be associated with the use of exclusive licenses generally (Hypothesis 2) and with product scope restricted exclusive licenses specifically (Hypothesis 3). *Early stage licensing* was also coded from news reports of the alliances; for example, a license that was '... directed to proof of principle experiments that will

[10] Three exclusive licenses are restricted by both geographic and product scope. In our judgment, the primary scope restriction in these licenses was geographic, and we coded them as such in the reported analyses. However, coding these licenses as restricted by product scope has no material impact on our results. In principle, license scope can also be restricted by distribution channel. However, our sample contains only two such cases and these licenses are also restricted by product.

[11] Monsanto & Millennium sign major genomics deal, 27 October 1997, thepharmaletter.com http://www.thepharmaletter.com/file/76123/monsanto-millennium-sign-major-genomics-deal.html (15 July 2009)

evaluate potential applications of the technology in infectious disease targets' would be coded as early stage. We also coded a dummy variable *other relationship* to capture any additional formal relationships between the firms participating in a licensing alliance. Most of these were equity relationships (67%), with the rest being reciprocal trading relationships. While this variable was used as a control in all our analyses, it is also 'interacted' (we address issues relating to interpreting interactions in choice models below) with *early stage licensing* to examine if these alternate formal mechanisms induce firms to choose unrestricted exclusive licensing in lieu of exclusive licensing that is restricted by product scope (Hypothesis 4).

We test our hypotheses about geographic scope (Hypotheses 5a and 5b) by examining the role of *marketing-only investment* (i.e., without other, specifically R&D, complementary investments), and by coding a dummy variable *international licensing* that measures if the technology flows across national boundaries in the license. In news reports, the strength of licensee capabilities within specific geographic areas were frequently mentioned in the context of international licensing alliances, and typically these were marketing capabilities. For example, 'partner with proven marketing capabilities and a strong Canadian sales force' or 'their strong reputation, expertise and their proven success in Japan.' Therefore, we also explored how these two factors affect geographic scope restrictions jointly by employing their interaction term(s).

We included a number of control variables, in addition to *other relationship*, in our analyses. We coded a dummy variable *past relationship* to proxy for any prior relationship (typically prior licensing) between the parties engaging in the license. This variable proxies the existence of informal relational governance between the parties based on reciprocity, reputations, trust, or mutual learning, which has been the focus of scholarly interest in the relationship between formal contracts and relational governance (Poppo and Zenger, 2002; Hoetker and Mellewigt, 2008; Ryall and Sampson, 2009). We include a control dummy variable *process technology*; set = 1 when process technologies are licensed for commercialization.[12] Similarly we control for *university technology* when technologies that originated in universities are later licensed between firms, which may reflect a chain of commercialization being mediated by start-ups (Stuart, Ozdemir, and Ding, 2007). Given the emphasis on market power in prior theoretical models of exclusivity, we include the variables *industry growth (3 year)* and *concentration (8 firm)*, which have been used in prior empirical work on licensing (Kim and Vonortas, 2006). Prior work on decisions to license have measured appropriability using broad industry-level indicators of patent effectiveness (Anand and Khanna, 2000; Arora and Ceccagnoli, 2006; Kim and Vonortas, 2006); however, our relatively narrow industry category dummies already control for such differences. We also coded two variables (log) *licensee assets* (in $ Mn.) and *asset ratio*, which is the ratio of (log) licensee to (log) licensor assets in the year of the license. These variables account for size effects in absolute and relative terms, respectively. We also included dummy variables for different industry categories of licenses in our data (see below), based on the SIC code assigned by SDC to each alliance. Finally, we coded a linear time trend variable *year* to account for any secular changes in licensing patterns over the time period of our sample.

Description of licensing data

In Figure 2, we present data on the size distribution (in assets) of licensors and licensees in our sample. Although it includes only publicly traded firms, our sample largely conforms to the widely held stereotype of small firms and start-ups licensing their technologies to larger firms with well-developed commercialization capabilities. The median ratio of licensee to licensor assets in our sample is about 21.4, and over 60 percent of licensor firms had assets below $100 Mn. However, there are also several examples in our data of large firms licensing to small firms who specialize in a narrow market (e.g., Dow licensing to Cytogen for a nuclear medicine product) and of licenses between small or medium-sized firms. Figure 3 shows the distribution of the ratio of licensee to licensor size in aggregate and also broken down by industry. Again, we see a pattern of largely small-to-large

[12] Because our sample consists of licenses entered into for the commercialization of technology, it comprises largely product technologies. When process technologies are in our sample, they typically cover a key technology for manufacturing a product.

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Table 1. Description of data by industry category

	Total	Pharmaceuticals & cosmetics (SIC codes) 2833–2834 & 2844	Diagnostics (SIC codes) 2835	Biological products (SIC codes) 2836	Other chemicals (SIC codes) 2810–2824 & 2851–2899	Research services (SIC codes) 87xx
Number of observations	265	51	38	110	27	39
	Mean (Std. err.)	Mean (Std. err.)	Mean (Std. err.)	Mean (Std. err.)	Mean (Std. err.)	Mean (Std. err.)
Exclusive licensing						
Exclusive (any type)	0.796 (0.025)	0.902 (0.042)	0.789 (0.067)	0.864 (0.033)	0.333 (0.092)	0.795 (0.065)
Worldwide exclusive	0.264 (0.027)	0.275 (0.063)	0.211 (0.067)	0.327 (0.045)	0.074 (0.051)	0.231 (0.068)
Exclusive by geography	0.340 (0.029)	0.392 (0.069)	0.289 (0.075)	0.382 (0.047)	0.148 (0.070)	0.359 (0.078)
Exclusive by product	0.208 (0.025)	0.235 (0.060)	0.316 (0.076)	0.182 (0.037)	0.111 (0.062)	0.205 (0.065)
Early stage licenses	0.528 (0.031)	0.490 (0.071)	0.553 (0.082)	0.618 (0.047)	0.185 (0.076)	0.564 (0.080)
Complementary asset investments						
Any investment	0.800 (0.025)	0.882 (0.046)	0.737 (0.072)	0.827 (0.036)	0.593 (0.096)	0.872 (0.054)
R&D investment	0.502 (0.031)	0.529 (0.071)	0.500 (0.082)	0.545 (0.048)	0.148 (0.070)	0.615 (0.079)
Manufacturing investment	0.249 (0.027)	0.255 (0.062)	0.211 (0.067)	0.218 (0.040)	0.556 (0.097)	0.154 (0.059)
Marketing investment	0.544 (0.031)	0.608 (0.069)	0.421 (0.081)	0.609 (0.047)	0.222 (0.082)	0.641 (0.078)
Prior relationship	0.155 (0.022)	0.176 (0.054)	0.158 (0.060)	0.145 (0.034)	0.148 (0.070)	0.103 (0.049)
Other relationship	0.189 (0.024)	0.196 (0.056)	0.158 (0.060)	0.182 (0.037)	0.148 (0.070)	0.256 (0.071)
International licensing	0.377 (0.030)	0.373 (0.068)	0.342 (0.078)	0.373 (0.046)	0.481 (0.098)	0.385 (0.079)

firm licensing, with (other) chemicals being the exception.

Table 1 provides an overview of our data, both in aggregate and broken down by five SIC-based industry categories: pharmaceuticals, diagnostics, biologicals, chemicals, and research services, respectively. Around 80 percent of the licenses in our sample are exclusive licenses, but only about 26 percent are exclusive and unrestricted in scope (exclusive worldwide). Geographic scope restrictions are more common (34% of all licenses) than product restrictions (21%). Approximately 53 percent of licenses are early stage and about 80 percent require complementary investments in commercialization, which are typically for R&D (50%) and/or marketing (54%). There are some interesting interindustry differences in these patterns. For example, the share of exclusive licensing of all types is low in (other) chemicals, and high in pharmaceuticals and biologicals, which are also more likely to entail commitments to invest in complementary assets. About 15.5 percent of licenses are between parties that have a prior relationship between them, and about 19 percent include other relationships along with the focal license, with no significant variation between industry segments in these characteristics. About 38 percent of licenses are international in character, with (other) chemicals again being the outlier (48%).

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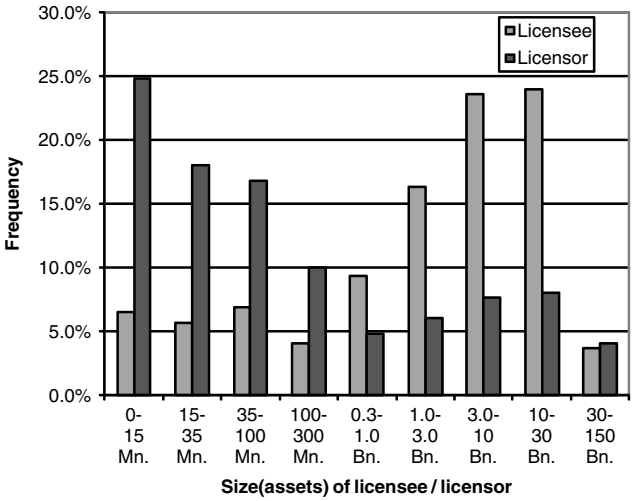

Figure 2. Size distribution of licensors and licensees in sample

Statistical models

We employ two types of models to analyze our data. First, we use a standard probit model to estimate the likelihood that a particular license is exclusive (versus nonexclusive). Estimation is by maximum likelihood, and robust (Huber-White) standard errors are reported. We then employ the multinomial logit approach (McFadden, 1974) to model the probability that a particular license falls into one of four mutually exclusive categories: nonexclusive, worldwide exclusive, exclusive with product restriction, or exclusive with geographic restriction. We use the focal category of scope restriction being tested (product or geographic) as the reference category in these models. By so doing, we are able to simultaneously examine the factors that distinguish the focal category from all other license types, and thus appreciate our findings more fully. We also estimated models with nonexclusive licensing as the reference category, and report one of these models with each set of results.

Employing the multinomial logit model implies an assumption that the choice between any two alternatives is not influenced by which other alternatives are in the choice set, often described as the independence of irrelevant alternatives (IIA) (McFadden, 1974). If decision making about exclusive licensing is nested, the IIA assumption will not hold, and using a multinomial logit model would be inappropriate. However, when we conducted Hausman chi-squared tests of the IIA hypothesis (Greene, 2000) we found no support for rejecting it in our data, thus corroborating our use of a multinomial logit model. We treat the alternate types of licensing as unordered choices in the model, which is also supported by a log likelihood test between the ordered and unordered models. The unordered multinomial logit model can be written as follows:

$$P(Y = j) = \frac{e^{\beta' X_{ij}}}{\sum_{j=1}^{J} e^{\beta' X_{ij}}}$$

where i indexes the alliance, and j indexes the type of licensing arrangement. Following the standard approach, the numerator is set = 1 for the reference category so that the model is identified.

RESULTS

Using the estimation sample of 232 observations, Table 2 provides means and standard errors for all of our variables, both for the entire sample and broken down by each choice category. Table 3 reports correlations. Table 4 shows the estimation results for our standard probit model. Model 1 in Table 4 reports estimates for only the control variables, including a full set of industry segment dummies ([other] chemicals is the omitted category). In Model 2, we add the variable *any investment*, and find that it has a strong positive effect on the

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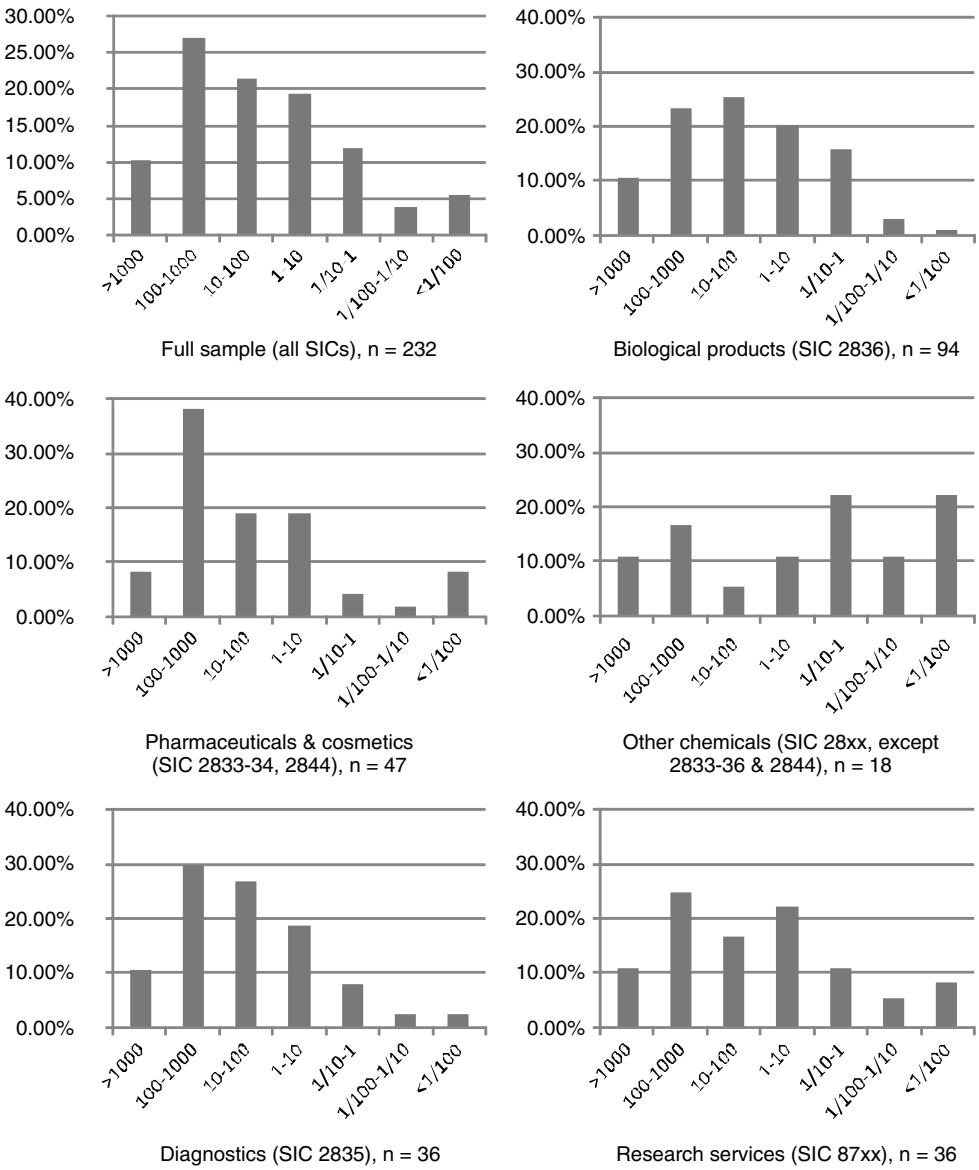

Figure 3. Relative size distribution of licensees to licensors (assets, in multiples)

likelihood of exclusive licensing (significant at the 1% level). Model 3 shows that *early stage licensing* also has a statistically significant association with exclusive licensing (at the 1% level). When complementary asset investments and *early stage licensing* are included in the same model (Models 4 and 5), the significance level of the latter falls to five percent. Thus, we find quite robust corroboration for Hypotheses 1 and 2; however, a fuller picture of early stage licensing will emerge when we examine product restrictions, below.

Estimates for the effects of investment in each of the different types of complementary assets (R&D, manufacturing, and marketing) are reported in Model 5. Interestingly there is no statistically significant association between *manufacturing investment* and exclusive licensing, but investments in R&D and marketing assets are associated with a higher probability of exclusive licensing (at the 5% and 1% levels, respectively). Therefore, it appears to be only necessary to grant licensees exclusivity when they are required to make complementary

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Table 2. Descriptive statistics of variables (means)

	All licensing	By type of licensing (dependent variables for multinomial logit model)			
		Nonexclusive licensing	Exclusive licensing with geographic restriction	Exclusive w/ product (field-of-use) restriction	Worldwide unrestricted exclusive licensing
Exclusive licensing	0.802 (0.400)	—	—	—	—
Any investment	0.810 (0.393)	0.522 (0.505)	0.878 (0.329)	0.896 (0.309)	0.875 (0.333)
R&D investment	0.534 (0.500)	0.304 (0.465)	0.338 (0.476)	0.771 (0.425)	0.750 (0.436)
Manufacturing investment	0.250 (0.434)	0.304 (0.465)	0.216 (0.414)	0.167 (0.377)	0.313 (0.467)
Marketing investment	0.534 (0.500)	0.152 (0.363)	0.811 (0.394)	0.417 (0.498)	0.578 (0.498)
Early stage licensing	0.565 (0.497)	0.348 (0.482)	0.378 (0.488)	0.792 (0.41)	0.766 (0.427)
International licensing	0.461 (0.500)	0.37 (0.488)	0.757 (0.432)	0.313 (0.468)	0.297 (0.46)
Other relationship	0.220 (0.415)	0.13 (0.341)	0.311 (0.466)	0.063 (0.245)	0.297 (0.46)
Past relationship	0.159 (0.367)	0.130 (0.341)	0.122 (0.329)	0.188 (0.394)	0.203 (0.406)
Year	4.608 (2.778)	5.000 (2.582)	4.121 (2.852)	5.063 (2.913)	4.547 (2.69)
Process technology	0.047 (0.213)	0.152 (0.363)	0.027 (0.163)	0.021 (0.144)	0.016 (0.125)
University technology	0.082 (0.275)	0.043 (0.206)	0.081 (0.275)	0.042 (0.202)	0.141 (0.35)
Industry growth (3 yr)	44.264 (40.36)	31.684 (39.456)	48.354 (39.975)	44.076 (38.453)	48.718 (41.84)
Concentration (8 firm)	58.652 (15.622)	55.526 (15.286)	59.642 (16.262)	60.9 (14.918)	58.067 (15.591)
Pharmaceuticals & cosmetics	0.203 (0.403)	0.087 (0.285)	0.230 (0.424)	0.229 (0.425)	0.234 (0.427)
Diagnostics	0.159 (0.367)	0.174 (0.383)	0.149 (0.358)	0.229 (0.425)	0.109 (0.315)
Biological products	0.405 (0.492)	0.283 (0.455)	0.459 (0.502)	0.313 (0.468)	0.5 (0.504)
Research services	0.155 (0.363)	0.174 (0.383)	0.149 (0.358)	0.167 (0.377)	0.141 (0.35)
Other chemicals	0.078 (0.268)	0.283 (0.455)	0.014 (0.116)	0.063 (0.245)	0.016 (0.125)
Licensee assets ($ Mn.)	7179.1 (9807.2)	8880.3 (15466.3)	6311.0 (6882.0)	7699.5 (9427.7)	6569.7 (7552.2)
Asset ratio (licensee/licensor in logs)	0.934 (2.812)	0.882 (0.672)	0.756 (0.57)	1.596 (6.007)	0.680 (0.965)
Observations	232	46	74	48	64

Note: Figures in parentheses are standard deviations.
* Pharmaceuticals & cosmetics = SIC 2833–2834 & 2844, Diagnostics = SIC 2835, Biological products = SIC 2836, Research services = SIC 87xx, Other chemicals = SIC 2810–2824 & 2851–2899.

investments in R&D and marketing, which are more likely to be in technology-specific intangibles. Manufacturing investments, which may be less specific to licensed technologies and therefore less susceptible to holdup or opportunism, do not appear to need an exclusive license. In the last column, Table 4 reports the estimated marginal effects for each of the variables in the probit model (Model 5) when the other variables are held at their mean. We find that (controlling for other variables at their mean) the likelihood of observing exclusivity increases by about 11.3 percent with investment in complementary R&D, by 31.7 percent with investment in complementary marketing, and by 10.6 percent for early stage licenses.

Tables 5 and 6 report estimates from multinomial logit models, where exclusive licensing with product scope restriction is the reference category in Table 5 and with geographic scope restriction in Table 6. We designate the focal type of licensing in our hypotheses (3–5) as the reference category for these models so that we may compare the likelihood of choosing the focal license type versus each of the others. Thus, each model reported consists of three columns of estimates, corresponding to each alternative form of licensing other than the reference category. Each table also reports estimates from a model with nonexclusive licensing as the reference category (as in Table 4), which provides a useful comparison to other models in the table. We discuss the magnitude of the estimated hypothesized relationships using relative risk ratios, which can be easily obtained by taking exponents of the coefficients, and are interpreted like odds ratios in (ordinary) logit models.

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Table 3. Correlation matrix

Variable	*1.*	*2.*	*3.*	*4.*	*5.*	*6.*	*7.*	*8.*	*9.*	*10.*
1. Exclusive licensing	—									
2. Unrestricted exclusive	0.31*	—								
3. Geographic restriction	0.34*	−0.42*	—							
4. Product restriction	0.26*	−0.33*	−0.29*	—						
5. Any investment	0.37*	0.10	0.12	0.12	—					
6. R&D investment	0.23*	0.27*	−0.27*	0.25*	0.52*	—				
7. Manufacturing investment	−0.06	0.09	−0.05	−0.09	0.20*	−0.02	—			
8. Marketing investment	0.38*	0.05	0.38*	−0.09	0.43*	−0.02	0.19*	—		
9. Early stage licensing	0.22*	0.25*	−0.26*	0.24*	0.20*	0.58*	−0.08	−0.05	—	
10. International licensing	0.09	−0.20*	0.41*	−0.16*	−0.02	−0.12	−0.07	0.15*	−0.22*	—
11. Other relationship	0.11	0.12	0.15*	−0.18*	0.04	0.06	−0.09	0.08	0.07	0.01
12 Past relationship	0.04	0.07	−0.07	0.03	−0.03	0.01	0.08	−0.02	0.03	0.05
13. Year	−0.07	−0.01	−0.12	0.08	0.09	0.13*	−0.01	0.07	0.11	−0.07
14. Process technology	−0.25*	−0.09	−0.07	−0.07	0.01	−0.12	0.25*	−0.20*	−0.17*	0.04
15. University technology	0.07	0.13*	−0.00	−0.05	0.06	0.12	−0.03	0.06	0.14*	−0.12
16. Industry growth (3 yr)	0.16*	0.07	0.07	0.00	−0.00	−0.02	−0.02	0.05	0.01	0.08
17. Concentration (8 firm)	0.10	−0.02	0.04	0.10	0.08	0.15*	−0.04	0.07	0.15*	0.05
18. Pharmaceuticals & cosmetics	0.14*	0.05	0.05	0.04	0.13*	0.04	−0.02	0.04	−0.03	−0.01
19. Diagnostics	−0.02	−0.08	−0.02	0.11	−0.09	−0.04	−0.03	−0.11	−0.02	−0.01
20. Biological products	0.12	0.12	0.08	−0.09	−0.01	0.07	−0.03	0.10	0.16*	0.06
21. Research services	−0.03	−0.02	−0.01	0.00	−0.01	0.04	−0.08	0.04	−0.01	−0.04
22. Other chemicals	−0.38*	−0.14*	−0.16*	−0.04	−0.07	−0.18*	0.24*	−0.15*	−0.20*	−0.04
23. Log Licensee assets	0.07	−0.03	0.10	0.00	−0.03	−0.08	0.04	0.06	0.03	0.19*
24. Asset ratio	0.01	−0.06	−0.04	0.11	0.04	0.04	−0.04	−0.06	−0.11	−0.06

	11.	*12.*	*13.*	*14.*	*15.*	*16.*	*17.*	*18.*	*19.*	*20.*	*21.*	*22.*	*23.*
11.	—												
12.	−0.03	—											
13.	−0.16*	−0.14*	—										
14.	0.03	0.07	−0.18*	—									
15.	−0.05	0.04	−0.05	0.01	—								
16.	0.04	0.06	−0.27*	−0.08	0.05	—							
17.	−0.04	−0.06	−0.09	−0.18*	0.04	0.39*	—						
18.	−0.03	0.04	0.10	−0.01	−0.07	−0.10	−0.14*	—					
19.	−0.06	−0.03	0.02	−0.10	0.04	0.14*	0.15*	−0.22*	—				
20.	0.01	0.00	−0.26*	−0.10	0.04	0.22*	0.57*	−0.42*	−0.36*	—			
21.	0.12	0.01	0.31*	−0.10	0.00	−0.19*	−0.54*	−0.22*	−0.19*	−0.35*	—		
22.	−0.04	−0.04	−0.13	0.47*	−0.03	−0.18*	−0.31*	−0.15*	−0.13	−0.24*	−0.12	—	
23.	−0.06	0.05	−0.04	0.08	−0.02	0.05	−0.00	0.11	−0.02	−0.03	−0.03	−0.03	—
24.	−0.02	−0.05	−0.03	−0.02	−0.04	0.04	0.01	−0.04	−0.04	0.04	0.01	0.03	−0.12

Because we use the focal type of license as the reference category in Tables 5 and 6, negative signs for variable estimates represent a positive association with that license type. So, Model 2 in Table 5 indicates that *early stage licensing* is associated with a strong preference for product restricted exclusive licensing over nonexclusive licensing (at the 5% level), and with a weaker preference for product restricted exclusive licensing over geographically restricted exclusive licenses (at the 10% level). In this model, *early stage licensing* does not significantly discriminate between product restricted exclusive licenses and unrestricted exclusive licenses. Model 2 also shows a strong association between *other relationships* and both geographically restricted and worldwide exclusive licensing (over product restricted exclusive licensing), which we explore further in Model 3 through interactions between *other relationships* and *early stage licensing*. Choice models are nonlinear, therefore simple interaction terms are hard to interpret (Hoetkar, 2007) and we resort

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Table 4. Probit estimates and marginal effects[i] of the likelihood that a licensing alliance is exclusive

	Model 1	Model 2	Model 3	Model 4	Model 5	Marginal effects (5)
	Exclusive licensing	Exclusive licensing	Exclusive licensing	Exclusive licensing	Exclusive licensing	Exclusive licensing
Any investment		1.514**		1.433**		
		(0.272)		(0.272)		
R&D investment					0.745*	0.116*
					(0.319)	(0.053)
Manufacturing investment					−0.332	−0.055
					(0.329)	(0.059)
Marketing investment					1.789**	0.311**
					(0.294)	(0.058)
Early stage licensing			0.673**	0.461*	0.702*	0.112*
			(0.203)	(0.225)	(0.305)	(0.053)
International licensing	0.259	0.344	0.477*	0.502*	0.284	0.041
	(0.213)	(0.232)	(0.205)	(0.227)	(0.248)	(0.037)
Other relationship	0.392	0.445	0.317	0.383	0.154	0.021
	(0.286)	(0.31)	(0.294)	(0.311)	(0.339)	(0.043)
Past relationship	0.007	0.191	−0.024	0.149	0.232	0.03
	(0.301)	(0.34)	(0.3)	(0.336)	(0.333)	(0.039)
Year	−0.03	−0.066	−0.043	−0.077+	−0.106*	−0.016*
	(0.039)	(0.042)	(0.041)	(0.044)	(0.048)	(0.007)
Process technology	−0.992+	−1.319*	−0.88+	−1.209+	−0.43	−0.082
	(0.542)	(0.639)	(0.532)	(0.631)	(0.544)	(0.129)
University technology	0.521	0.509	0.388	0.383	0.267	0.033
	(0.473)	(0.598)	(0.479)	(0.558)	(0.566)	(0.06)
Industry growth	0.004	0.005	0.004	0.005	0.006	0.001
	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)	(0.001)
Concentration	−0.02*	−0.034**	−0.022*	−0.035**	−0.039**	−0.006**
	(0.008)	(0.011)	(0.009)	(0.011)	(0.012)	(0.002)
Pharmaceuticals & cosmetics	2.035**	2.162**	2.023**	2.156**	2.285**	0.17**
	(0.47)	(0.535)	(0.475)	(0.536)	(0.55)	(0.043)
Diagnostics	1.421**	2.023**	1.424**	2.03**	2.349**	0.149**
	(0.467)	(0.531)	(0.471)	(0.533)	(0.568)	(0.036)
Biological products	1.819**	2.248**	1.731**	2.181**	2.027**	0.273**
	0.459	−0.511	0.473	0.519	−0.551	(0.087)
Research services	1.023*	1.014*	0.946*	0.997*	0.946+	0.089*
	(0.458)	(0.493)	(0.458)	(0.493)	(0.505)	(0.038)
Log licensee assets	0.035	0.047	0.026	0.039	0.055	0.008
	(0.043)	(0.047)	(0.043)	(0.047)	(0.05)	(0.007)
Asset ratio	0.049	0.053	0.089	0.084	0.125	0.018
	(0.062)	(0.069)	(0.07)	(0.081)	(0.082)	(0.012)
Constant	0.067	−0.467	−0.064	−0.512	−0.269	
	(0.602)	(0.675)	(0.623)	(0.696)	(0.719)	
Observations	232	232	232	232	232	
Log pseudolikelihood	−93.023	−76.28	−89.024	−74.846	−67.927	

Note: Robust standard errors are in parentheses. ** significant at 1%; * significant at 5%; + significant at 10%.
i The marginal effects of variables are measured at the mean of all variables as the estimated change in the probability of observing exclusive licensing given a small change in the value of the focal variable. We add marginal effects because estimated coefficients lack a clear interpretation in probit models (Hoetkar, 2007).

instead to an approach that minimizes ambiguity by decomposing the 'interactions' of any pair of dummy variables (DVs) into four categories (both 0, DV1=0 DV2=1, DV1=1 DV2=0, both 1). The first of these is treated as the omitted category, and the remaining three are included as dummy variables in the model.

Our estimates with these interaction variables (Model 3) show that *early stage licensing* discriminates strongly (at the 5% level) between product

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Table 5. Multinomial logit estimates for exclusive licensing with product scope restriction

Reference category:	Model 1			Model 2			Model 3			Model 4		
	Exclusive licensing: Product scope restriction			Exclusive licensing: Product scope restriction			Exclusive licensing: Product scope restriction			Nonexclusive licensing		
	Non-exclusive licensing	Exclusive licensing: Geographic restriction	Exclusive licensing: Unrestricted Worldwide	Non-exclusive licensing	Exclusive licensing: Geographic restriction	Exclusive licensing: Unrestricted Worldwide	Non-exclusive licensing	Exclusive licensing: Geographic restriction	Exclusive licensing: Unrestricted Worldwide	Exclusive licensing: Geographic restriction	Exclusive licensing: Product restriction	Exclusive licensing: Unrestricted Worldwide
R&D investment	−2.527**	−2.278**	−0.126	−1.867*	−1.697**	0.051	−1.878*	−1.632**	0.099	0.246	1.878*	1.977**
	(0.632)	(0.55)	(0.536)	(0.746)	(0.628)	(0.602)	(0.739)	(0.622)	(0.602)	(0.739)	(0.739)	(0.72)
Manufacturing investment	1.247	0.255	0.943	1.063	0.168	0.838	1.126	0.14	0.787	−0.985	−1.126	−0.338
	(0.805)	(0.665)	(0.606)	(0.811)	(0.639)	(0.604)	(0.82)	(0.639)	(0.598)	(0.698)	(0.82)	(0.708)
Marketing investment	−2.219**	1.915**	0.355	−2.394**	1.835**	0.357	−2.419**	1.931**	0.431	4.35**	2.419**	2.851**
	(0.604)	(0.569)	(0.481)	(0.643)	(0.601)	(0.492)	(0.664)	(0.628)	(0.505)	(0.676)	(0.664)	(0.641)
Early stage licensing				−1.684*	−1.205+	−0.417						
				(0.713)	(0.686)	(0.715)						
International licensing	0.661	2.159**	0.007	0.253	1.976**	−0.126	0.291	1.951**	−0.137	1.66**	−0.291	−0.428
	(0.592)	(0.559)	(0.509)	(0.608)	(0.571)	(0.515)	(0.621)	(0.578)	(0.517)	(0.573)	(0.621)	(0.558)
Other relationship	0.989	2.387**	2.22**	1.311	2.465**	2.234**						
	(0.986)	(0.787)	(0.789)	(0.874)	(0.76)	(0.761)						
Early stage licensing*							−0.461	1.548	2.011+	2.009+	0.461	2.472*
Other relationship							(1.244)	(1.074)	(1.135)	(1.077)	(1.244)	(1.1)
Early stage licensing*							−1.59*	−1.513*	−0.534	0.077	1.59*	1.056
No other relationship							(0.763)	(0.766)	(0.809)	(0.76)	(0.763)	(0.764)
No early stage licensing*							1.112	1.43	1.484	0.318	−1.112	0.372
Other relationship							(1.411)	(1.095)	(1.192)	(1.232)	(1.411)	(1.352)
Past relationship	−0.919	−1.153+	−0.199	−0.822	−1.163*	−0.192	−0.831	−1.161*	−0.201	−0.329	0.831	0.63
	(0.71)	(0.592)	(0.571)	(0.665)	(0.581)	(0.553)	(0.666)	(0.561)	(0.552)	(0.663)	(0.666)	(0.648)
Year	0.151	−0.117	0.056	0.187+	−0.097	0.069	0.181+	−0.101	0.07	−0.281*	−0.181+	−0.111

Table 5. (*Continued*)

Reference category:	Model 1			Model 2			Model 3			Model 4		
	Exclusive licensing: Product scope restriction			Exclusive licensing: Product scope restriction			Exclusive licensing: Product scope restriction			Nonexclusive licensing		
	Non-exclusive licensing	Exclusive licensing: Geographic restriction	Exclusive licensing: Unrestricted Worldwide	Non-exclusive licensing	Exclusive licensing: Geographic restriction	Exclusive licensing: Unrestricted Worldwide	Non-exclusive licensing	Exclusive licensing: Geographic restriction	Exclusive licensing: Unrestricted Worldwide	Exclusive licensing: Geographic restriction	Exclusive licensing: Product restriction	Exclusive licensing: Unrestricted Worldwide
	(0.097)	(0.104)	(0.096)	(0.101)	(0.107)	(0.1)	(0.1)	(0.106)	(0.1)	(0.116)	(0.1)	(0.113)
Process technology	0.535	0.694	−1.295	0.137	0.192	−1.492	0.166	0.041	−1.558	−0.126	−0.166	−1.724
	(1.48)	(1.243)	(1.52)	(1.263)	(1.182)	(1.514)	(1.253)	(1.202)	(1.548)	(1.083)	(1.253)	(1.267)
University technology	0.679	2.017	2.02+	0.71	1.988+	1.894+	0.729	1.994+	1.875+	1.265	−0.729	1.146
	(1.598)	(1.316)	(1.125)	(1.428)	(1.195)	(1.037)	(1.395)	(1.182)	(1.033)	(1.496)	(1.395)	(1.418)
Industry growth	−0.007	0.001	0.01+	−0.009	0.001	0.011+	−0.009	0.001	0.011+	0.01	0.009	0.02+
	(0.01)	(0.007)	(0.006)	(0.01)	(0.008)	(0.006)	(0.01)	(0.007)	(0.006)	(0.011)	(0.01)	(0.011)
Concentration	0.037	−0.027	−0.088**	0.04	−0.035	−0.092**	0.041	−0.035	−0.093**	−0.075*	−0.041	−0.133**
	(0.025)	(0.026)	(0.026)	(0.027)	(0.028)	(0.028)	(0.028)	(0.03)	(0.029)	(0.03)	(0.028)	(0.033)
Pharmaceuticals & cosmetics	−1.907+	3.192*	2.883*	−2.032+	3.182**	2.974*	−2.011+	3.298**	3.087*	5.308**	2.011+	5.097**
	(1.138)	(1.318)	(1.38)	(1.16)	(1.184)	(1.379)	(1.148)	(1.195)	(1.372)	(1.154)	(1.148)	(1.424)
Diagnostics	−2.771*	2.68+	2.468+	−2.762*	2.891*	2.697+	−2.72*	2.978*	2.8+	5.698**	2.72*	5.52**
	(1.189)	(1.52)	(1.501)	(1.226)	(1.462)	(1.528)	(1.188)	(1.457)	(1.504)	(1.45)	(1.188)	(1.625)
Biological products	−1.279	3.603*	4.466**	−1.159	3.92**	4.671**	−1.139	3.984**	4.774**	5.123**	1.139	5.913**
	(1.131)	(1.418)	(1.501)	(1.185)	(1.416)	(1.571)	(1.18)	(1.442)	(1.556)	(1.409)	(1.18)	(1.622)
Research services	−0.476	2.127+	0.929	−0.568	2.109+	1.024	−0.509	2.214*	1.086	2.723*	0.509	1.595
	(1.087)	(1.275)	(1.285)	(1.03)	(1.144)	(1.281)	(1.015)	(1.111)	(1.26)	(1.073)	(1.015)	(1.303)
Log licensee assets	−0.156	−0.014	−0.051	−0.134	0.002	−0.045	−0.132	−0.0001	−0.046	0.132	0.132	0.086
	(0.113)	(0.108)	(0.083)	(0.115)	(0.11)	(0.084)	(0.116)	(0.11)	(0.084)	(0.125)	(0.116)	(0.108)
Asset ratio	−0.273	−0.14	−0.164	−0.404	−0.225	−0.198	−0.373	−0.194	−0.195	0.179	0.373	0.178
	(0.246)	(0.272)	(0.141)	(0.282)	(0.297)	(0.157)	(0.251)	(0.229)	(0.13)	(0.245)	(0.251)	(0.236)
Constant	1.417	−1.718	1.464	1.839	−1.058	1.669	1.75	−1.081	1.651	−2.831+	−1.75	−0.099
	(1.554)	(1.835)	(1.516)	(1.612)	(1.787)	(1.523)	(1.581)	(1.787)	(1.511)	(1.699)	(1.581)	(1.588)
Observations		232			232			232			232	
Log pseudolikelihood		−203.929			−199.682			−198.804			−198.804	

Note: Robust standard errors are in parentheses. ** significant at 1%; * significant at 5%; + significant at 10%.

Table 6. Multinomial logit estimates for exclusive licensing with geographic scope restriction

Reference category:	Model 1			Model 2			Model 3			Model 4		
	Exclusive licensing: geographic scope restriction			Exclusive licensing: geographic scope restriction			Exclusive licensing: geographic scope restriction			Nonexclusive licensing		
	Non-exclusive licensing	Exclusive licensing: product restriction	Exclusive licensing: unrestricted Worldwide	Non-exclusive licensing	Exclusive licensing: product restriction	Exclusive licensing: unrestricted worldwide	Non-exclusive licensing	Exclusive licensing: product restriction	Exclusive licensing: unrestricted worldwide	Exclusive licensing: geographic restriction	Exclusive licensing: product restriction	Exclusive licensing: unrestricted worldwide
R&D investment	−0.326	1.449*	1.518**									
	(0.684)	(0.563)	(0.48)									
Manufacturing investment	1.082+	0.106	1.003*	0.909	−0.167	0.72	0.879	−0.152	0.727	−0.879	−1.032	−0.152
	(0.65)	(0.597)	(0.504)	(0.713)	(0.651)	(0.543)	(0.676)	(0.658)	(0.544)	(0.676)	(0.811)	(0.703)
Marketing investment	−4.33**	−1.943**	−1.578**									
	(0.629)	(0.562)	(0.488)									
Marketing investment*				−4.357**	−0.148	0.101	−4.357**	−0.215	0.055	4.357**	4.142**	4.413**
R&D investment				(1.123)	(0.875)	(0.729)	(1.121)	(0.874)	(0.72)	(1.121)	(1.092)	(1.033)
Marketing investment*				−4.432**	−1.823*	−2.048**						
No R&D investment				(0.822)	(0.902)	(0.777)						
No Marketing investment*				−0.553	1.435	1.138	−0.567	1.383	1.091	0.567	1.951*	1.659*
R&D investment				(0.938)	(0.907)	(0.747)	(0.949)	(0.899)	(0.741)	(0.949)	(0.878)	(0.804)
Early stage licensing	−0.319	1.48*	0.928+	−0.488	1.22+	0.744	−0.496	1.259+	0.761	0.496	1.755*	1.257+
	(0.64)	(0.65)	(0.515)	(0.66)	(0.694)	(0.546)	(0.681)	(0.699)	(0.545)	(0.681)	(0.748)	(0.675)
International licensing				−1.752**	−1.988**	−2.105**						
				(0.568)	(0.569)	(0.468)						
Marketing investment (w/o R&D)* International							−6.038**	−4.147**	−4.236**	6.038**	1.891	1.802
							(0.993)	(1.227)	(1.124)	(0.993)	(1.257)	(1.216)
Marketing investment (w/o R&D)* Not international							−4.372**	−1.482	−1.832*	4.372**	2.89**	2.541*
							(1.039)	(0.999)	(0.829)	(1.039)	(1.063)	(1.074)
No marketing investment (w/o R&D)* International							−1.682*	−1.777**	−1.939**	1.682*	−0.095	−0.257
							(0.678)	(0.65)	(0.546)	(0.678)	(0.681)	(0.609)
Other relationship	−0.826	−2.273**	−0.016	−1.177	−2.472**	−0.259	−1.172	−2.476**	−0.263	1.172	−1.305	0.909
	(0.756)	(0.743)	(0.489)	(0.854)	(0.752)	(0.532)	(0.853)	(0.749)	(0.526)	(0.853)	(0.887)	(0.825)
Past relationship	0.137	0.999+	0.756	0.36	1.186*	0.965+	0.368	1.189*	0.967+	−0.368	0.821	0.598
	(0.686)	(0.603)	(0.588)	(0.699)	(0.581)	(0.554)	(0.701)	(0.586)	(0.563)	(0.701)	(0.666)	(0.652)

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Table 6. (*Continued*)

Reference category:	Model 1			Model 2			Model 3			Model 4		
	Exclusive licensing: geographic scope restriction			Exclusive licensing: geographic scope restriction			Exclusive licensing: geographic scope restriction			Nonexclusive licensing		
	Non-exclusive licensing	Exclusive licensing: product restriction	Exclusive licensing: unrestricted Worldwide	Non-exclusive licensing	Exclusive licensing: product restriction	Exclusive licensing: unrestricted worldwide	Non-exclusive licensing	Exclusive licensing: product restriction	Exclusive licensing: unrestricted worldwide	Exclusive licensing: geographic restriction	Exclusive licensing: product restriction	Exclusive licensing: unrestricted worldwide
Year	0.282**	0.088	0.143	0.281*	0.094	0.162	0.283*	0.096	0.165	−0.283*	−0.186+	−0.118
	(0.106)	(0.095)	(0.096)	(0.117)	(0.106)	(0.105)	(0.116)	(0.107)	(0.105)	(0.116)	(0.101)	(0.115)
Process technology	−0.605	−0.893	−2.58*	0.069	−0.024	−1.607	0.045	0.026	−1.612	−0.045	−0.019	−1.657
	(1.105)	(1.229)	(1.272)	(1.096)	(1.179)	(1.219)	(1.123)	(1.179)	(1.216)	(1.123)	(1.329)	(1.273)
University technology	−0.789	−1.416	0.399	−1.338	−2.043+	−0.157	−1.319	−1.983+	−0.124	1.319	−0.664	1.194
	(1.425)	(1.134)	(0.682)	(1.522)	(1.197)	(0.811)	(1.509)	(1.174)	(0.793)	(1.509)	(1.432)	(1.448)
Industry growth	−0.011	−0.002	0.008	−0.009	−0.001	0.011+	−0.009	−0.001	0.01+	0.009	0.008	0.019+
	(0.011)	(0.007)	(0.006)	(0.012)	(0.007)	(0.006)	(0.012)	(0.007)	(0.006)	(0.012)	(0.01)	(0.011)
Concentration	0.075**	0.036	−0.051+	0.074*	0.034	−0.059+	0.073*	0.035	−0.058+	−0.074*	−0.038	−0.132**
	(0.028)	(0.026)	(0.027)	(0.03)	(0.029)	(0.031)	(0.031)	(0.029)	(0.031)	(0.031)	(0.027)	(0.032)
Pharmaceuticals & cosmetics	−5.642**	−3.62**	−0.664	−5.069**	−3.045**	−0.009	−5.115**	−3.023**	−0.011	5.115**	2.092+	5.105**
	(1.216)	(1.284)	(1.276)	(1.138)	(1.16)	(1.267)	(1.141)	(1.152)	(1.271)	(1.141)	(1.163)	(1.464)
Diagnostics	−6.139**	−3.427*	−0.838	−5.585**	−2.792+	−0.076	−5.646**	−2.844*	−0.131	5.646**	2.802*	5.515**
	(1.426)	(1.415)	(1.488)	(1.457)	(1.444)	(1.609)	(1.488)	(1.476)	(1.634)	(1.488)	(1.224)	(1.681)
Biological products	−5.588**	−4.503**	−0.011	−4.956**	−3.795**	0.87	−4.994**	−3.785**	0.857	4.994**	1.209	5.852**
	(1.366)	(1.408)	(1.484)	(1.37)	(1.403)	(1.588)	(1.379)	(1.422)	(1.617)	(1.379)	(1.183)	(1.653)
Research services	−3.166**	−2.633*	−1.597	−2.625*	−2.02+	−1.056	−2.678*	−1.969+	−1.044	2.678*	0.71	1.634
	(1.124)	(1.183)	(1.3)	(1.093)	(1.122)	(1.323)	(1.107)	(1.127)	(1.331)	(1.107)	(1.024)	(1.342)
Log licensee assets	−0.189	−0.072	−0.116	−0.138	−0.001	−0.049	−0.139	−0.006	−0.056	0.139	0.134	0.084
	(0.115)	(0.098)	(0.092)	(0.124)	(0.113)	(0.096)	(0.126)	(0.113)	(0.096)	(0.126)	(0.12)	(0.106)
Asset ratio	−0.261	0.126	−0.116	−0.169	0.235	0.039	−0.171	0.213	0.016	0.171	0.384	0.188
	(0.242)	(0.169)	(0.138)	(0.282)	(0.292)	(0.194)	(0.277)	(0.284)	(0.19)	(0.277)	(0.265)	(0.243)
Constant	2.837+	1.017	2.667	3.054+	1.026	3.097+	3.06+	0.903	3.044	−3.06+	−2.158	−0.016
	(1.711)	(1.73)	(1.744)	(1.783)	(1.92)	(1.84)	(1.806)	(1.956)	(1.859)	(1.806)	(1.632)	(1.599)
Observations		232			232			232			232	
Log pseudolikelihood		−212.634			−199.095			−198.82			−198.82	

Note: Robust standard errors are in parentheses. ** significant at 1%; * significant at 5%; + significant at 10%.

restrictions and geographic restrictions (as well as nonexclusive licensing) when *other relationships* are absent. We also find that unrestricted exclusive licensing is preferred over product restricted exclusive licensing when *early stage licensing* is accompanied by *other relationships*. While this coefficient is only significant at the 10 percent level, we can reject even more strongly the hypothesis that it is the same as the coefficient for *early stage licensing* in the absence of *other relationships* (+1.789 is statistically different from −0.556 at the 5% level). We also note that *other relationships* have no meaningful impact on licensing choices outside of *early stage licensing*. In Model 4, we find that relative to nonexclusive licensing, early stage technologies are associated with unrestricted exclusive licensing when these other relationships are present and with product restricted exclusive licensing when they are absent (both at the 5% level). We also estimated models where the interactions with equity and reciprocal trading are examined separately and found comparable results (similar magnitudes but lower significance levels for reciprocal trading, which may be expected because it is more infrequent in the data).

Taken together, these results suggest that firms prefer unrestricted exclusive licensing for early stage technologies in the presence of equity and reciprocal trading relationships that may mitigate transactional concerns, but employ exclusive licensing with product scope restrictions when these other relationships are absent. The magnitudes of these effects are quite large. Early stage licensing without other relationships increases the relative risk of choosing product restricted exclusive licensing (over nonexclusive and geographically restricted exclusive licensing) by a little over four times, which corresponds to a doubling in raw probability of choosing product restricted exclusive licensing starting from the average levels in our sample (an increase of 21.7 percentage points). When other relationships are present, early stage licensing increases the relative risk of choosing unrestricted exclusive licensing over product restricted exclusive licensing by 6.86 times.

International licensing and *marketing-only investments* are both strongly associated with geographically restricted exclusive licenses when compared with all other types of licensing (Model 2, Table 6). The high statistical significance of these coefficients (1% to 5%) suggests strong corroboration for Hypotheses 5a and 5b. Generally, the magnitudes of these coefficients are larger than those for early stage licensing, and indicate a much larger impact on the choice of licensing type (especially in terms of risk ratios). There is no relation between R&D-only complementary investments and the use of geographic restrictions, which is also consistent with our predictions. In Model 3 (Table 6), we explore how the 'interactions' between these two variables influence the choice of geographic scope restrictions. We adopt the same approach for decomposing interactions as the one used above. Model 3 shows an extremely strong relationship between choosing geographic scope restrictions and licensing that is both international and entails marketing-only investments. The magnitudes of these coefficients are some of the largest in our results and imply relative risks that are higher by 55 (coeff=4.01) to 265 (coeff=5.581) times, which in turn increases the probability of choosing exclusive geographically restricted licensing (starting from average sample levels) to 97.5 percent! Model 4 further shows that the relevance of these variables is quite specific to geographically restricted exclusive licensing; only marketing investments undertaken jointly with R&D investments or domestic licensing have an impact on choosing other types of exclusive licenses.

DISCUSSION

In this paper we have sought to understand the role played by exclusivity in technology licensing relationships. While prior theoretical work has modeled the exclusive licensing decision primarily through the lens of product market structure and secondarily by considering the appropriability conditions for technology, our research illuminates the use of exclusivity structures to address the contractual challenges for *collaboration* between innovators and owners of complementary assets. This approach helps to explain not only the exclusivity decision itself but also the limitations placed on the scope of these exclusive rights through product and geographic restrictions. Furthermore, we present a set of systematic empirical analyses, which corroborates our propositions and explores the phenomenon of exclusive licensing in depth for the first time. While our findings do have some limitations, they also contribute to the literatures

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on alliances and licensing in a number of ways, which are discussed below.

Robustness checks and limitations

We conducted a number of robustness checks on our results to evaluate their sensitivity to alternate specifications. Some of these analyses are visible in the results we have already presented; for example, we differentiate between different (functional) types of licensee complementary investments and evaluate multinomial models with different reference categories to examine systematic patterns in the data. We also employed alternate measures of our *early stage licensing* and *other relationship* variables—using third stage clinical trials and only equity relationships, respectively—and found very similar results as the ones we report. In addition, because (other) chemical technologies appear to be somewhat different in their licensing characteristics (see Table 1 and related discussion) we also estimated all our models by excluding these nonmedical chemicals licenses, and again found similar results. In analyses conducted without our two financial controls, we found that our findings are also not sensitive to exclusion of the 33 observations for which we had no financial data.

One potential limitation of this study is that our empirical findings may not generalize to other technologies and industries, which also suggests fruitful avenues for future work. For example, in electronics and information technologies, the challenges posed by fast paced innovation, standards-setting, and complex systems products may interact with early stage technologies and complementary asset investments to create additional drivers of exclusive licensing. In these technologies, many licenses may also be arm's-length IP transactions, including cross-licensing deals (Grindley and Teece, 1997), licensing to settle IP disputes (Somaya, 2003), and licenses accompanying 'scale' alliances (like R&D or standards consortia—see Dussauge, Garrette and Mitchell, 2000). Licensing by research institutions (e.g., universities, hospitals, and government laboratories) is another interesting setting, where exclusivity terms may be influenced by public policy and scientific goals in addition to the motivations examined in this study. In addition, our sample excludes private firms, particularly pre-IPO start-ups, and the compulsions of these firms in choosing exclusivity terms may not be well represented by our findings. One valuable direction for future work may be to examine the impact of financial constraints faced by private firms on the structure of licensing alliances. Finally, while potential licensee knowledge exploration (and the appropriability hazards it creates) is integral to our theorizing and findings about early stage licensing, there may be other ways in which knowledge exploration impacts licensing structure, which can be investigated in future research.

Implications for Alliances Research

In the sizable literature that has mushroomed around the study of alliances, attention has increasingly turned toward the specific structures that firms employ to balance trade-offs between various collaborative benefits and challenges in their interorganizational arrangements (Parkhe, 1993; Ring and Van de Ven, 1992; Ariño and Reuer, 2006; Hagedoorn and Hessen, 2007; Reuer and Ariño, 2007). The research in this paper advances this new thrust in alliances research by examining the drivers of an important structural feature of licensing alliances, namely exclusivity, and further illuminating the subtle trade-offs entailed in the use of different exclusivity provisions. We find evidence consistent with the use of exclusivity as a contractual hostage for licensing early stage technologies and when licensees are required to make technology-specific complementary investments. While the idea of using hostages to facilitate interorganizational relationships has been known for some time (Williamson, 1983), we add to the relatively limited research examining specific types of hostage exchange in management (Deeds and Hill, 1999; Chen and Hennart, 2004; Ahmadjian and Oxley, 2006). We propose that exclusivity is a particularly effective hostage because it commits the licensor to the alliance without simultaneously providing the licensee with many opportunities for misappropriation.

Consistent with prior alliances research (Oxley and Sampson, 2004) we find that limiting the scope of an alliance may help to manage high transactional hazards. Specifically, our evidence suggests that licensing hazards related to highly uncertain early stage technologies can be mitigated by limiting the scope of the (exclusive) license to some products. We further clarify the mechanism underlying scope limitation in alliances, and conclude that it is effective because transactional hazards

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and value creation possibilities are typically not correlated across the potential set of domains for the alliance. We also propose, and find evidence consistent with, a second related motivation for scope limitations that has not been examined in prior alliances research, namely the limited scope of the complementary capabilities that are being transacted through the alliance. Ultimately, both arguments for scope limitations reflect a similar logic of marginal trade-offs between contractual hazards and value creation possibilities.

In our empirical work, we uncovered some interesting additional nuances that are also of interest to alliances research. We found, for example, that while specific investments in complementary R&D and marketing were associated with an increased likelihood of exclusive licensing, investments in manufacturing were not. This finding suggests that, unlike the intangibles entailed in R&D and marketing investments, manufacturing investments may be inherently more redeployable even when initially dedicated toward a particular use. It also lends support to the broader proposition that there may be systematic differences in the challenges of transacting over property-based and knowledge-based assets between firms (Hoetkar and Mellewigt, 2006). While we find virtually no relationship between relational governance (measured by past relationships) and formal contractual structures, which has been the focus of much recent scholarship (Poppo and Zenger, 2002; Hoetkar and Mellewigt, 2006; Ryall and Sampson, 2009), we uncovered some evidence that formal contractual structures and other formal relationships may substitute for each other in interfirm alliances. Our results suggest that product scope limitations may be used to manage high licensor hazards created by early stage (exclusive) licensing, but only when there are no other relationships in place that may serve a similar function. This is not an entirely surprising finding because if an alternate mechanism can be used to address contractual hazards, retaining unrestricted scope for the alliance may have value for adaptation and flexibility over time.

Implications for Licensing Research

Our examination of exclusive licensing provisions builds on research that has highlighted the important role played by complementary assets in licensing (Teece, 1986; Arora and Ceccagnoli, 2006). In contrast with theoretical models that predict the use of exclusive licensing to diminish *ex post* competition in product markets or provide early stage incentives for innovation (Gallini and Wright, 1990; Kamien and Tauman, 1986; Oster, 1995), our results suggest that exclusive licensing may play a central role in overcoming barriers to coordinating over complementary assets that are necessary for technology commercialization. This view of exclusivity as a contractual hostage that facilitates cooperation between licensee and licensor is one that has not hitherto been systematically explored. We find robust evidence that these transaction cost considerations are an important predictor of exclusive licensing, a finding that is also consistent with anecdotal descriptions of exclusive licensing considerations. In turn, the contractual challenges of licensor-licensee collaboration also appear to explain the use of scope restrictions to limit the domain(s) of exclusive rights bartered away in licensing.

While access to commercialization capabilities is widely recognized as a motivation for licensing, the challenges of accessing them are generally underestimated in formal models. In particular, our results suggest that theoretical models of licensing may need to move away from the assumption that the licensee participation constraint is zero economic profits, and to acknowledge the value and isolating mechanisms embedded in licensee complementary assets. Further, building on Jensen and Thursby (2001), our results suggest that licensing research needs to be further informed by the challenges posed by uncertain early stage technologies, and that strategies to address technology-related uncertainties can be important for facilitating licensing alliances.

Our study also contributes to the still small empirical literature on strategic choices in licensing (Taylor and Silbertson, 1978; Caves *et al.*, 1983; Anand and Khanna, 2000; Kim and Vonortas, 2006). By developing a sample of licenses in a narrow set of industries and coding it at a greater level of detail than prior studies, we are able to answer important questions about drivers of licensing strategy that have not been addressed in prior work. In addition to explaining the use of exclusive licensing itself, we contribute to this line of work by more closely studying different types of exclusivity provisions in technology licenses. We advance our understanding of product and geographical restrictions in licensing scope

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by theorizing and demonstrating that such scope restrictions may be a mechanism for firms to manage the balance between transactional hazards and cooperative benefits in different licensing contexts.

Finally, our research also has implications for technology commercialization professionals and executives who structure and manage licensing alliances. Licensing is potentially a very attractive avenue for unlocking value from innovation, which can simultaneously benefit innovators, entrepreneurs, and complementary asset providers alike. However, licensing alliances are also plagued by myriad challenges arising from collaboration between distinct entities who must commit specialized and valuable resources in a highly uncertain environment where there are few safeguards. Our research suggests that there are solutions to address these challenges by structuring and shaping licensing alliances to address transactional concerns, while at the same time retaining the potential for creating value through the combination of complementary technologies and resources.

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