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TECHNOLOGY COMMERCIALIZATION STRATEGY IN A DYNAMIC CONTEXT

DEVELOPING SPECIALIZED COMPLEMENTARY ASSETS IN ENTREPRENEURIAL FIRMS

DAVID H. HSU, THE WHARTON SCHOOL, UNIVERSITY OF PENNSYLVANIA
SIMON WAKEMAN, ESMT

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Abstract

Technology commercialization strategy in a dynamic context: Developing specialized complementary assets in entrepreneurial firms[+]

Author(s):* David H. Hsu, The Wharton School, University of Pennsylvania
Simon Wakeman, ESMT

A firm that lacks the specialized complementary assets necessary to commercialize an innovation faces a trade-off between contracting with an incumbent to access those assets and integrating downstream into commercialization. According to the framework developed in the prior literature, under a strong appropriability regime the innovator is likely to be better off contracting with an incumbent (as long as it can negotiate reasonable terms). However, we argue that if the innovator can learn from its experience in product commercialization, and thereby build its own commercialization capabilities, then the benefits of integrating downstream may outweigh the opportunity costs of learning and foregone profits. Alternatively, by engaging in joint commercialization, the innovator may be able to avoid these opportunity costs, albeit at the expense of higher inter-organizational governance costs. We illustrate the relationship between the choice of commercialization mode, commercialization experience, and performance in the context of the pharmaceutical industry. Specifically, we study how commercialization mode and experience affects the likelihood of drug approval. We find that when innovators lacking commercialization experience participate in the commercialization process though either joint commercialization or by commercializing alone, the product is less likely to be approved. However, innovators that have participated in the commercialization process in the past are more likely to successfully commercialize subsequent innovations under joint commercialization than those which have only contracted the commercialization to an incumbent. The results suggest that in some circumstances participating in the commercialization process, either through self-commercialization or by engaging in joint commercialization, may be the optimal strategy even for firms without the requisite complementary assets.

Keywords: Complementary assets, technology commercialization strategy, entrepreneurial firms, strategic alliances, alliance structure

* Contact: Simon Wakeman, ESMT, Schlossplatz 1, 10178 Berlin,
Phone: +49 (0) 30 21231-1285, simon.wakeman@esmt.org.

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1 Introduction

The manager of a start-up firm founded to commercialize an innovation must not only decide how to bring its current innovation to market, but also how best to develop its organization in order to capture value from future innovation. The literature on technology commercialization strategy (TCS), initiated by Teece (1986) and developed by Gans & Stern (2003) among others, addresses the first decision by providing a framework for choosing the optimal commercialization mode. It characterizes the innovator's decision as a one-off choice between contracting with an incumbent (e.g., licensing) or integrating downstream to commercialize the innovation itself. The optimal choice depends – among other things – on the strength of the appropriability regime surrounding the innovation and the innovator's position in any requisite complementary assets.[1] If the appropriability regime is strong (i.e., the threat of expropriation is low) but the innovator does not have the requisite specialized complementary assets (e.g., access to a particular distribution channel), the innovator faces a tradeoff. On the one hand, contracting with an incumbent allows the innovator access to the incumbent's complementary assets, but entails sharing the returns with the incumbent (unless the innovator is in a particularly strong bargaining position). Integrating into commercialization, on the other hand, allows the innovator to avoid sharing the profits, but because it relies on its own, inferior complementary assets, the risk of commercialization failure increases and/or the value created may be smaller.

The existing literature on TCS does not, however, address the broader organizational issues that technology-based entrepreneurs face. Under the existing TCS framework, an innovator that generates subsequent innovations remains in the same organizational position in commercializing each innovation, and so faces the same trade-off between a lower likelihood of success and sharing returns. In contrast, we argue that if the innovator can learn from its commercialization experience, and thereby develop its own specialized complementary assets, it may be able to avoid having to make the same tradeoff with future innovations. The most obvious way in which it may develop downstream commercialization capabilities is by commercializing the innovation alone (i.e., "integrating into commercialization"). The direct exposure to the commercialization process should enable it to learn from its experience and thereby develop expertise in how to commercialize innovations. However, commercializing alone is difficult and costly, as compared to a cooperative commercialization strategy, both because of the higher risk of failure (as above) and because learning new organizational routines to incorporate new processes may result in

[1] Gans & Stern (2003) consider a broad interpretation of contracting, or cooperative strategies, including technology licensing, alliance relationships, or outright acquisition of startups. In this study, we treat arms-length technology licensing and alliances differently, as they have different precursors and methods of reinforcement in use (as per Aggarwal & Hsu, 2009).

less productive product development. Therefore an intermediate strategy, joint commercialization, in which the innovator contracts with an incumbent to perform the commercialization but remains involved in the commercialization process, may be a superior way both to commercialize its current innovation and to acquire specialized complementary assets. Compared to a straight contracting arrangement, the organization engaging in joint commercialization has the opportunity to develop specialized complementary assets, though the likelihood of commercialization success is lower than under contracting due to higher transaction costs associated with joint commercialization. Compared to commercializing alone, the development of complementary assets associated with joint commercialization is likely expedited and may ultimately be more successful, although with the additional costs associated with governing the inter-organizational relationship.

We extend the existing TCS framework by allowing the innovator to develop organizational-level capabilities through its commercialization experience, and analyze how taking into account the long-run effects of the innovator acquiring its own commercialization capabilities impacts the optimal choice of commercialization mode. We also add joint commercialization to the set of possible commercialization modes and describe the conditions under which this strategy will be preferred to the alternatives. We then illustrate the trade-off between the short- and long-run effects of commercialization mode choice in the context of commercialization performance in the biopharmaceutical industry. Specifically we show how both commercialization-mode choice and experience in the different commercialization modes are related to the likelihood that the innovator's product reaches the market.

The next section develops the theoretical framework, showing the determinants that influence the choice of commercialization mode, including joint commercialization. We then turn our attention to the empirical analysis in which we examine the relationship between commercialization mode choice, commercialization-mode experience, and product-development success. Before doing so, we wish to emphasize two caveats on our analysis. First, while we develop a broader decision framework guiding innovators' choice of commercialization mode (including costs and benefits associated with various modes), we are unable to untangle the drivers of commercialization-mode choice in our empirical work. Instead we treat the choice of commercialization mode as exogenous in our empirical analysis. Second, although in our theoretical discussion we make arguments based on the different types of costs and benefits associated with choosing the different commercialization modes, in our empirical work we are unable to identify the precise mechanisms relating either commercialization-mode choice or commercialization-mode experience to product development performance.

2 Theoretical framework

2.1 Relationship to the prior literature

This paper builds on the framework proposed in Teece's (1986) seminal paper on "Profiting from Technological Innovation". Teece framed TCS as a choice between contracting with an established firm versus commercializing alone, and identified the appropriability regime surrounding the innovation and the innovator's position in specialized complementary assets as the key determinants shaping that decision. In particular, he argued that if the innovation is protected by a strong appropriability regime but the innovator is "disadvantageously positioned" vis-à-vis the owners of the complementary assets (the incumbents) then the innovator should contract with an incumbent if it can do so on competitive terms, or alternatively vertically integrate (see Teece, 1986, Figure 10). However, since the innovator in his framework innovates only once, Teece did not consider how its commercialization mode choice might affect its options for commercializing future innovations. Moreover, although he acknowledged that the innovator that contracts for access will have to share profits with the holders of the complementary assets, he did not consider how it can overcome its disadvantaged position and thereby earn superior profits over the long term. Furthermore, although Teece mentions that firms may use "mixed modes" in transitional phases (Teece, 1986, p.298), he did not explicitly consider how a firm may use an intermediate arrangement between contracting and vertically integrating to establish a position of competitive advantage.

Most of the prior TCS literature treats organizational development of specialized complementary assets as given. For example, Chesbrough et al. (2006), writing on the 20-year anniversary of Teece's 1986 paper, conclude: "Teecian complementary assets take the innovation and corresponding value chain as more or less given and consider what are the requirements for commercialization." (p. 1096). This lack of attention to the development of complementary assets is perhaps because most of the literature approaches technology commercialization from the incumbent's perspective. For example, Tripsas (1997) finds that specialized complementary assets can insulate incumbents from market leadership displacement in the face of disruptive innovation. Likewise, Rothaermel (2001) finds that incumbent alliances leveraging their complementary assets are more productive following technology disruption. Moreover, the studies that do not take complementary assets as fixed tend to skirt the direct issue of how firms develop the requisite complementary assets. For example, Arora & Ceccagnoli (2006) show that the payoffs to commercialization strategy depend on the difficulty and costs of assembling the relevant complementary assets but do not address how firms overcome this constraint. Some recent work has illustrated how firms might alter their relative competitive positioning by weakening complementary asset

owners' bargaining position (Jacobides, Knudsen & Augier, 2006; Pisano & Teece, 2007), but do not examine how the innovator can do so directly by strengthening its own complementary assets.

There is a small literature on TCS that explicitly takes the standpoint of the startup entrant. Gans, Hsu & Stern (2002) and Gans & Stern (2003) consider how startup commercialization strategy depends on the business environment, and posit that the innovator's ability to prevent a potential partner from imitating or inventing around the innovation affects their relative bargaining power and therefore the range of commercialization strategies available to the innovator. However, they too treat organizational complementary assets as given. (See also Arora & Merges (2004) for a formal treatment of the relationship between appropriability and commercialization strategy.)

Some recent literature has shown that taking a dynamic view of TCS may lead to different conclusions regarding optimal TCS. Gans (2011) finds that while an innovator may find a "cooperative" TCS of partnering with an incumbent optimal in a static context, the opportunity to acquire capabilities may instead suggest that integrating into commercialization ("competition") may put the innovator in a stronger position to lead the next round of innovation. He does not, however, analyze the various factors that may make one strategy superior the other, nor does he consider whether a hybrid strategy such as joint commercialization may dominate either alternative. Marx, Gans & Hsu (2013) show that it may be optimal for an innovator to first choose a vertically integrated strategy in order to establish credibility and then "pivot" to a cooperative licensing strategy, under circumstances where the static framework predicts that it should attempt to cooperate from the beginning,. However, under their framework building downstream capabilities that can be used for future innovations is considered a disadvantage and the "pivoting" strategy is more likely to be optimal when the innovator can easily reverse its investments in complementary assets.

There is a large, related literature on learning through alliances (see, for instance, Hamel, 1991; Khanna, Gulati & Nohria, 1998; Oxley & Sampson, 2004), a subset of which focuses on how the structure of the alliance may affect learning (Kogut, 1988; Mowery, Oxley & Silverman, 1996).[2] However, this literature is primarily focused on horizontal, "knowledge sharing" alliances (in the parlance of Grant & Baden-Fuller, 2004) between firms with complementary technological portfolios, such as international technology alliances, in which learning from the other firm is the primary objective. By contrast, this paper focuses on the structure of vertical arrangements in which learning is often secondary to the primary objective of accessing an incumbent's commercialization skills. Hence, although some of

[2] Kogut (1988) argues that joint ventures may be more effective for achieving knowledge transfer while Mowery et al. (1996) show empirically that firms are more likely to achieve technological transfer through bilateral (versus unilateral) contracts.

the insights from that literature are relevant here, the different and arguably more complicated objectives in this context raise their own issues.

2.2 A dynamic technology commercialization strategy framework

As discussed above, the existing TCS literature analyzes the choice of commercialization mode only in the context of what is optimal for capturing value from the current innovation. This implies that if the innovator engages in repeated innovation then the optimal choice of commercialization mode will be the same each time it attempts to commercialize an innovation. However, if the innovator's choice of commercialization mode for earlier innovations affects its relative position in the requisite complementary assets in later innovations then it may be better off over the long run choosing a commercialization mode that is suboptimal in the short run (i.e., under the 'one shot' framework envisioned by the existing TCS literature). Hence allowing for repeated innovation and taking into account how the choice of commercialization mode impacts organizational-capability development may alter the predictions about the optimal TCS.

Specifically, the existing TCS framework posits that if the innovator is at a disadvantage relative to the incumbents in commercializing an innovation, then a contractual relationship with the incumbent is preferred (assuming that the appropriability regime is sufficiently strong that it can capture a proportionate share of the returns). However, if commercializing alone enables the innovator to build its commercialization experience and capabilities and thereby puts it in a better position to commercialize subsequent innovations, then it may be optimal for the innovator with weak commercialization capabilities to commercialize alone from the outset. Building its own commercialization capabilities increases the chances that it will be able to successfully commercialize subsequent innovations by itself over the long term and thereby avoid sharing profits with an incumbent. In addition, by improving the credibility of its outside option to commercialize its innovation alone, the innovator strengthens its position in negotiations and may thereby be able to obtain better terms in any subsequent commercialization deals with an incumbent. By contrast, continuing to contract with an incumbent leaves it in the same (disadvantaged) position when it comes to commercializing subsequent innovations.[3] However, although commercializing alone potentially strengthens the innovator's position over the long term, it incurs opportunity costs in the short run due to having to draw on its own (inferior) capabilities and from having to invest in learning. Hence extending the TCS framework to allow the innovator to

[3] In fact, as Pisano (1990) pointed out, if the incumbent firm acquires (additional) specialized knowledge by performing the commercialization, continuing to contract with the incumbent may put the innovating firm at a greater disadvantage relative to the incumbent (due to increased asset specificity).

learn from its commercialization experience introduces a trade-off between the expected long-term benefits and the short-run opportunity costs.

Joint commercialization, an intermediate strategy in which the innovator contracts with the incumbent to commercialize its current innovation but remains involved in the commercialization process alongside the incumbent firm, potentially mitigates the disadvantages of the original two choices and may be superior to either contracting with an incumbent or commercializing alone under certain circumstances. Under joint commercialization, the innovator has access to the incumbent's superior capabilities for commercializing the current innovation and so avoids the initial disadvantages associated with self-commercialization. Participating in the commercialization process alongside an incumbent firm opens the possibility of "learning by doing". Moreover, the innovator obtains access to the incumbent's specialized knowledge regarding the commercialization process and so may acquire more valuable knowledge than it would acquire under self-commercialization. Furthermore, the incumbent's involvement is likely to increase the likelihood of successful commercialization and therefore the opportunities to learn.

Nevertheless, if the innovator chooses a joint commercialization strategy it will still incur short-run costs (relative to straight contracting) similar to what it would face under self-commercialization, including the costs of learning and the foregone profits if it decreases the chances of success by participating in the process. Moreover, it may also incur higher transaction costs of governing the relationship (relative to straight contracting) because its efforts to acquire commercialization skills may reduce the incentive of its partner or act to avoid leaking unintended knowledge. Furthermore the incumbent will naturally have to perceive a distinct value proposition if it is to agree to a joint commercialization arrangement with the innovator (especially since joint commercialization potentially facilitates the creation of a new competitor) and may demand a greater share of the returns than it would under a straight contracting arrangement. Hence the choice between straight contracting, joint commercialization, and self-commercialization will depend on a trade-off between the long-run benefits and short-run costs.

Table 1 summarizes the characteristics of the alternative commercialization modes. In the next section we discuss the factors that determine the choice of commercialization mode under this enhanced TCS framework. In the following section we present a decision framework for choosing between the various modes based on the key elements that arise from this discussion.

2.3 Determinants of commercialization mode choice

The choice between these three alternative strategies will depend on:

- The expected benefits the innovator will receive by building specialized commercialization capabilities through (1) joint commercialization or (2) self-commercialization (relative to remaining without specialized capabilities).
- The opportunity costs that the innovator will incur in order to acquire those commercialization capabilities through (1) joint commercialization or (2) self-commercialization (relative to simply contracting an incumbent to do the commercialization).
- The innovator's ability to sustain the short-run opportunity costs due to (1) joint commercialization or (2) self-commercialization.
- The likelihood that the innovator will utilize the specialized commercialization capabilities in the future; and
- The relative bargaining power of the innovator and incumbent(s).

We now discuss these in turn.

2.3.1 Expected benefits of developing commercialization capabilities

The benefits to an innovator developing its own commercialization capabilities come mainly from higher returns when commercializing subsequent innovations. The first benefit of developing its own commercialization capabilities comes from being able to capture for itself the full share of any profits from commercializing any future innovation. If an innovator partners with an incumbent, it must share some of the profits with the incumbent in order to persuade an incumbent to commercialize its innovation. The share will depend on its bargaining power, but if the innovator has inferior commercialization capabilities then it will most likely give up a substantial share of the additional profits that come from using the incumbent's capabilities (relative to what it would obtain if it were to commercialize alone). By contrast, if it commercializes the innovation alone then it gets to keep the full share of the profits to itself. If its own commercialization capabilities are undeveloped then these profits are likely to be lower than its share of the profits if it were to commercialize with an incumbent. However, if it has developed its own specialized commercialization capabilities then the profits from commercializing alone should be at least as much and probably greater than if it shares the returns with an incumbent.

A second source of advantage from developing its own commercialization capabilities derives from positive spillovers that flow back into the innovator's ability to generate, identify, and capitalize on innovations (Teece, 1980). The information that an innovator obtains from developing and distributing an innovation may be valuable to the research and development of future products. For instance, in the

pharmaceutical industry having first-hand information on why physicians are – or are not – prescribing a drug can help focus research on the next generation product.[4]

Furthermore, having its own specialized commercialization capabilities can provide benefits even if the innovator chooses to partner with an incumbent to commercialize future innovations. Having an outside option to commercialize the innovation alone puts the innovator in a stronger position when it comes to negotiating how much it shares with a partner.[5] Moreover, having its own specialized commercialization capabilities may enable the innovator either to support its partner's commercialization activities or to monitor its partner's behavior when engaging in collaboration. Having its own specialized commercialization capabilities is also likely to make the innovator a more effective partner in a joint commercialization arrangement.

These benefits that the innovator receives will differ depending on whether it attempts to develop commercialization capabilities through a joint commercialization alliance or by commercializing alone. An advantage of commercializing alone is that the innovator gets direct experience of every aspect of the commercialization process and therefore – if it is successful – may acquire more tangible knowledge. However, the commercialization is less likely to be successful without access to an incumbent's superior commercialization capabilities and so the innovator's opportunities to learn will be more limited. Moreover, under a joint commercialization arrangement the innovator has the opportunity to observe the incumbent performing the commercialization activities and hence is likely to receive spillovers from the incumbent's superior knowledge. This will be especially valuable if that knowledge is embedded in its organizational routines and cannot easily be acquired by recruiting individuals. Hence in general an innovator is likely to receive higher benefits from developing commercialization capabilities through joint commercialization than through self-commercialization unless the structure of the contract or the nature of the commercialization process itself prevents the innovator from fully participating in and learning about the commercialization activities.

[4] In principle it may be possible to obtain this information through an alliance, but the downstream partner is in a position to withhold or obscure this information, especially if it affects the amount it must compensate the innovating firm. Hence integrating into commercialization may eliminate this type of incentive conflict, thus strengthening the information feedback from the product market to the R&D process.

[5] The shares of the returns will be a function of the respective bargaining positions of the two parties, particularly the quality of their outside options.

2.3.2 Opportunity costs

The innovator will incur most if not all the of opportunity costs of developing its own commercialization capabilities in the short run – that is, when commercializing the current innovation. There are three categories of opportunity costs that an innovator is likely to incur if it seeks to develop commercialization capabilities either through joint commercialization or self-commercialization, relative to the alternative where it engages in a straight contracting contract with an incumbent. The first category is the *learning costs* of acquiring the organizational capabilities, either through its own efforts or – in the case of a joint commercialization alliance – transferring them from a partner. The second category is the *foregone profits* that the firm incurs in the short run because it does not use the best commercialization capabilities available – the superior capabilities of an incumbent – to commercialize the innovation. Finally the third category, which arises specifically in the case of joint commercialization alliances, is the higher *transaction costs* associated with managing inter-organizational activities and incentivizing behavior, relative to a straight contracting arrangement.

Learning costs. Developing new organizational routines and capabilities to be in a position to commercialize subsequent innovations is a costly activity. There is a general notion in the literature on the resource-based view of the firm that acquiring or building valuable organizational resources and capabilities is a costly process (Barney, 1986; Dierickx & Cool, 1989; Winter, 2003). Focusing specifically on the case of a start-up firm that has been founded to commercialize a new innovation, the costs of acquiring new organizational capabilities are likely to be especially significant because the firm will not have the processes and absorptive capacity in place to receive new knowledge (Cohen & Levinthal, 1990). Incorporating knowledge from extramural sources is difficult even at the level of simple replication, and becomes especially challenging in contexts in which the desired output is novel. Scholars (e.g., Szulanski, 1996), have noted that the seemingly simple act of transferring established knowledge "modules" or best practices is notoriously difficult and costly, pointing to the complex organizational routines of creating, acquiring, storing, modifying, and transferring resources within and across organizational boundaries. Moreover the innovation context differs from the usual replication setting in the experience curve literature, in which fewer inputs are required to produce a given level of output as experience increases (or for a given level of input, output rises with experience), and hence these costs are likely to be even higher.

The literature on the costs of inter-organizational learning through alliances has recognized that characteristics of the focal firm-partner firm dyad influence possible knowledge absorption and benefits (Lane & Lubatkin, 1998; Stuart, 2000). However, there is limited discussion of what those costs entail and only a general notion that learning through alliances involves learning about the environment, task,

process, skills, and about the partner – and for each element, there are periods of learning, reevaluation, and readjustment (Doz, 1996).

In general the learning costs of self-commercialization are likely to exceed those of joint commercialization because the innovator in the former case essentially starts from scratch while in the latter case the innovator can draw on the incumbent's knowledge.

Foregone profits. If the innovator opts to participate in the commercialization of the innovation prior to developing its own commercialization capabilities then it is likely to forego a proportion of the profits (relative to what it would receive if were to contract with an incumbent to complete the commercialization). When an innovator commercializes alone, its inferior commercialization capabilities mean that the likelihood of commercialization success will be lower. Moreover, even if it is successful it may generate lower profits than if it were to contract with an incumbent because it lacks the incumbent's expertise. Even though an innovator that contracts with an incumbent will have to share some of the returns with the incumbent in order to obtain access to the incumbent's commercialization capabilities as well as transaction costs, using the incumbent's superior commercialization capabilities is likely to mean that the expected profits are higher (even after any transaction costs are taken into account) and so it will be able to offer the innovator a larger share of the profits than it would earn by commercializing alone. The difference translates into an opportunity cost that the innovator incurs if it commercializes alone rather than partners with an incumbent.

Under joint commercialization the innovator can draw on the incumbent's superior capabilities, but because the innovator lacks the commercialization expertise of the incumbent, its participation in the commercialization process is likely to increase the risk of failure and/or extend the time taken to commercialize the current innovation, relative to a straight contracting arrangement. Moreover, because joint commercialization enables the innovator to acquire knowledge about the commercialization process, it becomes more likely that the innovator will become a downstream competitor to the incumbent and thereby threaten the incumbent's future profit streams. Furthermore, for reasons discussed in more detail below, the cost of coordinating a joint commercialization arrangement between the two parties is likely to increase the overall costs of commercialization and hence reduce the profits that the incumbent would generate if it were to commercialize the innovation alone. All these reasons mean the incumbent firm will be worse off relative to under a straight contracting arrangement, and as a result is likely to offer less favorable terms (e.g., cash payments, royalties, etc.) than under a straight contracting arrangement. Hence the innovator will also incur an opportunity cost if it engages in joint commercialization relative to if it enters a straight contracting arrangement.

Transaction costs. Williamson (1975, 1985, 1996) argued that transaction costs arise in the context of inter-organizational relationships because managers are unable to resolve unanticipated events

by "fiat", as would be the case under vertical integration. One of the main transaction costs in alliances involving innovation or knowledge development result from efforts to guard against unintended knowledge leakage. Knowledge can flow easily between alliance partners, whether intended or not (Gomes-Casseres, Hagedoorn & Jaffe, 2006), and so knowledge appropriation can be a central concern even among alliance partners. The concern arises because alliances involving joint knowledge development necessitate permeable organizational boundaries, which makes it more difficult to demarcate and control the exact knowledge that flows across projects and firms, and this problem is exacerbated when there are multiple product development efforts spanning a range of contracting entities.

A related set of transaction costs discussed in the literature on "learning alliances" are those associated with avoiding a destructive "race to learn" between the parties (Hamel, 1991; Khanna et al., 1998; Baum, Calabrese & Silverman, 2000).[6] The literature has highlighted that both learning opportunities and rates can differ among the parties to an alliance, which can lead to racing to learn. As a result, one of the key managerial challenges is how to balance learning from alliance partners with protecting unintended leakage of own knowledge (Kale, Singh & Perlmutter, 2000).[7] This issue is especially important when a major objective for both parties is to acquire knowledge from the other through the alliance.

The risk is that, without appropriate alliance governance, an alliance may become unstable or dissolve completely because the more a partner learns (especially in an asymmetric fashion) or the greater the extent of knowledge leakage, the less necessary or desirable it becomes for the counterparty to continue the alliance (Hamel, 1991; Inkpen & Beamish, 1997; Gomes-Casseres et al., 2006). Moreover, despite the various governance mechanisms discussed in the literature, such as equity stakes and contractual covenants, inter-organizational governance can be costly and imperfect. Consequently, guarding against unintended knowledge spillovers to alliance partners can hinder the desired synergies and product development outcomes can suffer.

The literature on transaction costs also points to some of the incentive problems that may arise. According to contracting theory, when there is complete information, all actions are observable, and it is

[6] There does not appear to be any broad-based agreement in the literature as to what constitutes effective learning in alliances. For example, Hamel (1991) suggests that successful learning can take place even if the alliance fails more broadly; in contrast, Doz (1996) correlates failed alliance projects with inertial, non-learning situations. For this reason, we examine experience a marker of learning in our empirics.

[7] The relevance of these issues depends on the extent to which learning is a rivalrous good, and therefore has a zero-sum quality, as is implicitly assumed in the literature on learning races. The notion behind knowledge spillovers and racing is value capture. If the spillover of a unit of knowledge to a non-originating firm introduces competition to exploit a given application afforded by that knowledge, then the zero-sum quality probably prevails and learning races is likely to be a concern. If instead, firms can unleash commercial potential in different directions (e.g., Shane, 2000) without having an adverse effect on other uses, then the knowledge is non-rivalrous.

possible to contract on all contingencies, parties to a contract will have an incentive to maximize their joint welfare (see Salanie, 1997, for a summary). However, relaxing any of these conditions reduces the incentives of one or both parties to invest and/or exert effort in performing their contractual obligations. Moreover, if one party has multiple objectives or "tasks", it is likely to divert effort to the task which is easier to measure and/or more highly rewarded (Holmstrom & Milgrom, 1991). This weakens the incentives for the other to exert effort.

These points, taken together, highlight why parties to joint commercialization alliances may incur higher transaction costs relative to those entering a straight contracting arrangement. The bidirectional nature of knowledge sharing or "learning" under a joint commercialization alliance both increases the risk of knowledge leakage and also raises the possibility of a destructive "race to learn". Moreover, the incentive problems are likely to be more severe in joint commercialization alliances because the innovator's learning objective may divert its attention from the primary objective of commercializing the current innovation, and thereby weaken the incumbent's incentives to invest in the commercialization.

2.3.3 Inter-temporal considerations

The discussion above analyzed the benefits and costs of seeking to build commercialization capabilities by either engaging in a joint commercialization alliance or commercializing alone, relative to commercializing the innovation through a straight contracting arrangement. However, as mentioned, the innovator will incur the opportunity costs mainly in the short run (in commercializing the current innovation) while it will realize the benefits over the longer run. Therefore to evaluate the trade-off between the benefits and costs described above, it is necessary to take into account inter-temporal considerations. In particular: (1) the innovator must be in sufficiently strong financial position to engage in joint commercialization or commercialize the innovation alone; and (2) the innovator should be likely to commercialize future innovations in the same field for which the commercialization capabilities that it builds are specialized, and therefore be able to realize the benefits of building its own commercialization capabilities.

Financial position. The innovator must be in sufficiently strong financial position in order to engage in joint commercialization or commercialize the innovation alone. First and foremost, to realize the benefits of building its own commercialization capabilities over the long run the innovator must be able to sustain the (short-run) opportunity costs of doing so, in particular the upfront learning costs and lower expected profits from commercializing innovation, while it develops its capabilities. If incurring these costs may bankrupt the firm then it makes no sense to do so. Moreover, following this strategy should not permanently harm the firm's ability develop innovations in future. If the firm has to divert finance and/or attention from its R&D activities in order to invest in building commercialization

capabilities – whether alone or through a joint commercialization alliance – then it may permanently curtail the long-run benefits that it would receive from doing so. Thirdly, to persuade an incumbent to enter a joint commercialization alliance it must be able to offer sufficiently attractive terms. Aghion & Tirole (1994) demonstrated that if an innovator is financially constrained then ownership and/or control of the innovation will be allocated to a commercializing partner, even if it would be optimal (in the absence of financial constraints) for the innovator to retain ownership/control. This is because the financial constraints mean the innovator is unable to compensate the commercializing partner for giving up the benefits of ownership and control.

Field of specialization. Since the more valuable commercialization capabilities are specialized to a particular purpose (typically, a particular product field), they will only be useful to firms that innovate in that field in the future. For instance, in the pharmaceutical industry the value of commercialization capabilities turns on the strength of the firm's network to the hospitals and leading physicians that conduct clinical trials and prescribe breakthrough treatments. However, these will be specialized to a particular therapeutic field (e.g., cancer, or even a specific type of cancer) and will primarily be useful for commercializing future innovations in that area. If the innovator expects to commercialize future innovations in the same field as the current innovation then it makes more sense to invest in building commercialization capabilities either through a joint commercialization alliance or by commercializing alone. By contrast if the innovator perceives that an innovation is a "one off" in a particular field, then it is not likely to benefit – or as much – from building commercialization capabilities in that field and so may be better off contracting an incumbent to perform the commercialization.

2.3.4 Relative bargaining power of the innovator and incumbent(s)

Finally, in order to enter a joint commercialization alliance the incumbent must be willing to enter such an arrangement on acceptable terms. As mentioned above, allowing the innovator to enter a joint commercialization arrangement, and thereby develop its own commercialization capabilities, facilitates the creation of a competitor that may threaten the incumbent's own profit streams in the future. Hence, all else being equal, an incumbent may be unwilling to enter a joint commercialization arrangement with the innovator and insist on a straight contracting arrangement (or nothing).

The innovator's ability to negotiate a joint commercialization arrangement therefore depends on the relative bargaining power of the parties, which in turn reflects both the uniqueness of their positions and their outside options. If one incumbent has unique and highly specialized commercialization capabilities, then the innovator's choice of partners will be limited and it will be at a substantial disadvantage if it commercializes alone. On the flipside, if the innovation is both valuable and difficult to replicate then there is likely to be high demand from the incumbents to commercialize the innovation. The

innovator's ability to negotiate a joint commercialization arrangement will depend on how the respective positions of the two parties balance out.

2.4 Decision framework

Figure 1**Error! Reference source not found.** sketches a decision tree based on the key elements arising from the discussion above. As Figure 1 shows, the first decision node depends on whether the innovator is in a disadvantaged position in the requisite complementary assets relative to the incumbents. If not, the prediction of the existing TCS framework still holds – that is, the innovator commercializes alone (so long as doing so is consistent with its organizational aspirations). If it is at a disadvantage, the existing TCS framework indicates that the innovator should contract with an incumbent (as long as the IP regime is favorable). However, when we allow for the possibility that the innovator can learn from its commercialization experience and thereby build its commercialization capabilities, we have to take into account the various factors discussed above and the decision tree becomes more complicated.

The second decision node under this extended framework is whether the innovator is likely to commercialize in the same field in future. If not, the innovator is likely to be better off adopting a straight contracting strategy because building commercialization capabilities in that field would be redundant. On the other hand, if the innovator expects to engage in commercialization in the same field in the future, the third decision is whether the innovator has a sufficiently strong financial position to bear the opportunity costs of development and/or to strike an acceptable agreement via joint commercialization with a partner. The fourth decision node is whether the direct costs of building the commercialization capabilities – specifically, the costs of learning are within an acceptable range. These three conditions must all be satisfied for it to be worthwhile for the innovator to build its own commercialization capabilities, through either joint commercialization or self-commercialization.

If that is the case the subsequent decisions nodes determine the choice between joint commercialization and self-commercialization. One consideration is whether the incumbent is willing to engage in joint commercialization on reasonable terms. If an acceptable agreement is not likely to materialize then the innovator may consider either a straight contracting arrangement or self-commercialization, depending on the trade-off between the benefits of building its own commercialization capabilities and the opportunity costs of doing so. If an incumbent is offering acceptable terms, the final decision is whether the costs of governing the joint commercialization arrangement can be contained. If so then joint commercialization is likely to be the better option because the other opportunity costs are lower and the learning benefits higher under that arrangement; if not then self-commercialization is the better option.

3 Empirical analysis

We illustrate the trade-off that innovator makes between the benefits of building its own commercialization experience and the opportunity costs of doing so using a set of product-based innovations that were commercialized in the biopharmaceutical industry. Specifically, we investigate the relationship between the commercialization mode, the level and nature of the innovator's commercialization experience, and the performance of a product candidate in the commercialization process. Since we are unable – due to limitations of our data – to control completely for other factors that might explain the choice of commercialization mode, this empirical analysis does not provide a proper "test" of the framework outlined above. Nevertheless we believe that this analysis is helpful to demonstrate and tease out the ideas developed in the preceding section.

We start by motivating our empirical context and describing our data, then turn to a discussion of our variables and our empirical method.

3.1 Empirical context

We examine technology commercialization strategy in the context of innovative new pharmaceutical products developed by biotechnology firms. The typical biotechnology firm starts with a strong research base (often built from the founders' experience in university labs), yet does not have expertise in commercializing products or the downstream commercialization capabilities (such as a manufacturing plant or sales force) necessary to bring the innovation to market. Furthermore, lengthy and uncertain drug development means that a start-up firm is rarely able to finance commercialization completely from its own resources or even with only the help of venture capital finance. This combination of factors makes cooperation with industry incumbents attractive. Nevertheless, biotechnology firms report often that they do not capture a proportionate share of the value from an innovation purely through licensing (Wakeman, 2007), and there is a strong motivation to integrate downstream into the commercialization activities if and when it becomes possible. Hence they enter joint commercialization arrangements in order both to access the necessary commercialization capabilities and to learn from their partner in order to be able to commercialize subsequent product candidates, possibly alone. As a result, the industry provides an ideal setting to examine the consequences of commercialization mode choice and accumulated commercialization-mode experience.

3.2 Data sources and construction

We build our primary dataset from two related databases compiled by Deloitte Recap ("Recap"): RecapRx and rDNA. RecapRx contains a clinical development history for each indication of all products developed by the 146 largest biotechnology firms since their inception. rDNA contains detailed

information on all publicly announced alliances since the industry's inception, obtained from a combination of press releases and public filings. In addition we use information from IMS Lifecycle's R&D Focus database, the NBER patent dataset (Hall, Jaffe & Trajtenberg, 2001), the Derwent Innovations Index, and Compustat.

We start with the full set of products contained in the RecapRx database and the accompanying information on licensing and M&A activity related to these products. Using the more detailed information on licensing and M&A activity from rDNA, we determined which firm (or firms) owned the rights to sell the product in the United States for a specific indication for each month of the product's lifespan. If the rights were transferred, we recorded the nature of the transfer (i.e., whether the owner was acquired, the product was sold outright, or the product rights were licensed). If the transfer involved technology licensing, we collected information on the deal terms from rDNA, including whether the biotechnology firm retained the rights to participate in the development. Furthermore, we collected information on the clinical development history and the disease field to which the product relates (from RecapRx), the discovery date and the primary patents covering the underlying product (from IMS Lifecycle's R&D Focus database), and the citations to the primary patent (from the Derwent Innovations Index). Finally, we collected information on the characteristics of each firm, including the number of patents assigned to the firm (from the NBER patent file), the number of prior alliances (from rDNA), the number of products in its pipeline (from R&D Focus), and its total sales in the prior quarter (from Compustat).[8]

3.3 Empirical model

Our empirical analysis is designed to study the innovator's choice of commercialization mode for its current innovation, its experience in different commercialization modes, and product development performance.

3.3.1 Dependent variable

The dependent variable in our analysis is the performance – or success – of the product candidate in the commercialization process. We measure commercialization performance by whether the underlying alliance product successfully completed clinical trials and received FDA approval. If an originating firm

[8] All alliances in our dataset relate to an identifiable biopharmaceutical product. This contrasts with the alliance data used in most previous analyses of the biopharmaceutical industry, which contain a mixture of both technology- and product-related alliances. These different alliance types have different natural structures, and including both in the same analysis introduces unobserved heterogeneity. Since the alliances we study are focused on product commercialization (rather than technology development) we can be more confident that the parties were negotiating over similar issues. Moreover, we can also observe the outcome of the clinical development process, which gives us a clear measure of alliance performance.

commercializes the innovation alone then its return depends first on the product receiving approval and then selling on the market.[9] Similarly in a joint commercialization arrangement the originating firm typically receives its compensation in terms of a share of the profits from product sales, which can only be realized if the product is approved. In a straight-licensing arrangement the originating firm typically earns some upfront cash payments on signing and others on achieving some pre-approval milestones.[10] However, the largest share of return comes as a royalty on net sales, which it only realizes if the product is approved. Unfortunately we do not directly observe the share of the surplus between the innovator and the incumbent for the full set of products in our sample.[11] Nevertheless, because in most cases FDA approval is a necessary – and very important – condition for the innovator to receive any benefits we believe that it is a good proxy for the innovator's performance.

3.3.2 Explanatory variables

Our primary explanatory variables capture (1) commercialization mode, and (2) the level and nature of the originating firm's commercialization experience.

3.3.2.1 Commercialization mode

The first explanatory variable captures whether the innovator (1) licensed the rights to commercialize the product candidate for a specific indication exclusively to another firm (which we refer to as "straight licensing"); (2) licensed the rights to commercialize the product candidate for a specific indication to another firm but retained the rights to participate in development of the alliance product ("co-development"); (3) retained exclusive rights to the product candidate and attempted to commercialize it alone ("self-commercialization"); or (4) was acquired by another firm ("sale").[12]

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[9] The originating firm is the firm that owned the rights to the product at the beginning of the commercialization process. In principle this is the innovating firm, although as described below in some cases the product rights are transferred many times even before the product enters clinical development. Hence we define the originating firm as the firm that owns the rights at the beginning of clinical trials.

[10] There are several stages of drug development prior to involvement with the FDA (discovery, identification of lead molecule, preclinical trials) and after such involvement (small sample human safety, efficacy, and large scale clinical trials corresponding to Phase 1, 2, and 3 studies, respectively). Thereafter, when sufficient clinical data has been collected, the developer can apply to the FDA for approval (which allows the drug to be offered for sale).

[11] Using a related database produced by Deloitte Recap, Valuation Analyzer, we have obtained information on the effective royalty rate from the innovator negotiated for a fraction of the products, and we have used these to replicate the analysis on that subsample with a fractional probit specification (where the dependent variable is the innovator's effective royalty rate if the product is approved and 0 otherwise). The results are generally consistent with what we observe in the regressions on FDA approval, but because so many observations are missing we do not have confidence that the results are representative.

[12] We also observe if the originating firm sold the rights to the product outright, but treat this as equivalent to a straight-licensing arrangement because the innovator remains a stand-alone firm but does not learn anything from the commercialization of the product.

The standard arrangement for commercializing innovation in the biopharmaceutical industry is a straight licensing arrangement. The innovator licenses out the full set of rights to "make, use, and sell" the product to another firm, and in return receives a royalty based on a proportion of net sales. The innovator may still remain involved in the development of the product candidate, particularly when additional research is necessary, for example, to combine the product with a drug delivery mechanism but does not take an active role in conducting the clinical trials (or subsequently in marketing and selling the product).

By contrast, under a co-development arrangement the innovator participates in the design and conduct of the clinical trials, and has significant influence – if not an equal say – over whether the alliance product advances to subsequent stages of the development process.[13] Typically the innovator also incurs a share of the costs from development and takes a cut of the profit.

Prior interview research reveals that biotechnology firms commonly see co-development (and co-promotion, which is where the innovating firm participates in marketing and selling the product) as a way to acquire knowledge about the commercialization process that they can then apply to commercializing subsequent innovations (Wakeman, 2007). This arrangement enables the biotechnology firm to "piggy back" on the expertise of its alliance partner or to "leverage the alliance partner's expertise internally" to learn the skills necessary to develop the next drug. By contrast, Anand & Khanna (2000) found that the learning potential of straight licensing arrangements is limited.

Nevertheless, such terms can influence payoffs to alliance parties and can therefore affect their incentives (Parkhe, 1993). As discussed above, such deal terms may have a short-run incentive cost. If the partner allows the startup firm to share in the profits (e.g., revenue sharing based on product sales) the partner's benefits will be reduced. There may also be a number of indirect costs associated with limiting the partner's control over the commercialization process and instituting governance mechanisms to mitigate the risk of unintended knowledge spillovers. Facilitating development of downstream commercialization capabilities by the innovator may also, over the longer term, create competition for the alliance partner.

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[13] It is useful to contrast co-development arrangements to several other arrangements for commercializing biotechnology innovations. In a straight product license, the originating firm licenses all development, marketing, and distribution rights to its contracting partner. In such licensing arrangement, the originating firm delegates all rights to its alliance partner and typically is compensated just through milestone payment and a royalty on net sales. Alternatively, the parties may agree to split geographic territories, partitioning rights to develop, market, and/or sell the same drug in separate (exclusive) territories. A co-development arrangement should also be distinguished from a co-promotion arrangement in which the innovating firm licenses the marketing rights to a partner, but participates in the marketing and distribution process alongside the partner (i.e. the two parties together develop a joint marketing strategy and sales force, sell under the same brand name, and pool – and ultimately split – revenues). These two types of arrangement are not mutually exclusive, since an innovating firm that retains co-development rights can also retain co-promotion rights, but they are also not necessarily coincidental.

3.3.2.2 Prior commercialization experience

Our second explanatory variable captures the level and nature of the innovator's commercialization experience, specifically whether the innovator (a) had *any* experience in clinical development at phase 2 or higher (including as a passive licensor); (b) had prior experience in a co-development arrangement; and (c) had prior experience as the sole developer. We construct these variables from the innovator's full history of commercialization experience over all products that have been in its portfolio up to that date (determined from the RecapRx dataset). Because the first variable captures the effect of *any* experience, the latter two variables reflect the *incremental* effect of experience in a co-development arrangement and as a sole developer (respectively) relative to experience in a straight licensing arrangement. We construct the variable in this way because we are interested in how choosing co-development or self-commercialization affects performance *relative to the baseline of choosing a straight-licensing arrangement*.

3.3.3 Control variables

Our baseline analysis implicitly assumes that the choice of commercialization mode is determined exogenously. However, both the choice of commercialization mode and the likelihood of product approval may be related to characteristics of the originating firm and/or the underlying product. Hence in order to control for any bias than might be caused by omitted variables we include a number of variables that we believe may be correlated both with the choice of commercialization mode and whether the product is ultimately approved.

First, we include variables that control for the quality of the underlying product. The most obvious measure of "quality" is whether the product has shown sufficient promise in clinical trials for the developer to advance it to the next stage. We capture this with dummies for the highest stage of clinical trials the product had entered at the time it was transferred: pre-clinical or phase 1, phase 2, and phase 3. We also create an additional measure of the technological innovativeness of the product, based on the number of forward citations to the primary patent covering the product.[14] Finally we include product age and product age squared to control for the change in likelihood of approval over time.[15]

[14] Hall et al. (2005) validate the number of forward citations as a good proxy for a patent's economic value. Since we were unable to identify the primary patent for a number of products, several values of this variable are missing. To avoid having to drop these observations, we set the value of the missing variables equal to the mean and include a dummy variable that indicates the missing value in the regression.

[15] The likelihood of a product being approved increases over approximately the first 10 years, but then declines as the underlying patent approaches expiry.

Second, we control for the commercialization capabilities of both the innovator and its contracting partner. (For simplicity, henceforth we refer to these as "capabilities".) It is clear that these capabilities are likely to have a direct effect on whether the product is successfully commercialized. Moreover, a firm's capabilities can also shape the benefits it accrues from partners and hence affect the likelihood of commercialization indirectly. For example, a firm's capabilities affect the rate at which it is able to absorb commercial and technical knowledge from its partners (Mowery et al., 1996). Furthermore, firms with more experience, including partner-specific alliance experience (Reuer, Zollo & Singh, 2002), may be better able to manage and lead partners (Anand & Khanna, 2000). At the same time, the innovator's capabilities – both on their own and relative to the partner's capabilities – are likely to affect whether it is able to negotiate co-development rights. Having stronger capabilities gives the innovator a better outside option and hence puts it in a stronger bargaining position. Moreover, for the reasons discussed above, an innovator is more likely to retain co-development rights if it is in a stronger bargaining position. Nicholson, Danzon & McCullough (2005) find that inexperienced biotechnology firms face discounted deal terms when forming their first alliance, but afterwards these firms realize higher valuations from venture capitalists and the public-equity markets (controlling for product characteristics). More generally, a party that controls scarce resources enjoys stronger bargaining power and therefore can appropriate more of the value in the context of strategic alliances (Lavie, Lechner & Singh, 2007).

To measure each firm's commercialization capabilities, we create two different proxies and then use principal components analysis to construct a composite measure. Our first proxy is the firm's total sales in the prior quarter normalized by the highest total sales among all firms in the industry. We gathered quarterly data on firm sales for all firms in the pharmaceutical industry (i.e., firms with primary NAICS codes of 325411, 325412, 325413, or 325414) from Compustat, then ranked all firms by sales in each quarter, and finally normalized each firm's sales by the highest total sales of all firms in that quarter.[16] Our second proxy is the normalized count of products in the firm's portfolio (including those in its clinical development pipeline). To create this measure we count products at any stage of development with which the firm had been associated with at the time of the alliance.[17] To normalize the count, we

[16] The purpose of the normalization is to facilitate comparison across different time periods, since average firm sales in more recent years is likely to be higher than average firm sales in the early years of the biotechnology industry. As an alternative measure to check result robustness, we used the logged value of the raw total sales (while controlling for the month in which the alliance was signed).

[17] It is not possible to get accurate and comprehensive data on which firm had which rights to each product at each point in time, so instead we count any product with which the firm was associated (i.e., was either the originator or a licensee in any territory) at any time during the product's lifespan. This approach will overestimate the size of the pipeline but we do not have any reason to believe it will distort the measure in any way that would bias our results.

rank all firms by the number of products in their portfolio in that month and then divide by the highest number of products of any firm. Although this measure arguably represents size or experience rather than capabilities per se, our empirical analysis rests on the assumption that a firm's ability to commercialize products is likely to be strongly correlated with its experience and hence this is a good proxy for capabilities.

Finally, we include an indicator for whether the parties had a prior alliance together, constructed from the two parties' alliance history from rDNA. The prior literature has shown that the existence of a prior relationship between the parties can have an important effect on the way an alliance is managed and governed.

3.3.4 Alternative specifications

Matching on observables. If the set of products for which the originating firm is able to retain co-development are inherently different than those for which it enters into a straight licensing agreement, then simply including control variables may not account for unobserved heterogeneity. To deal with this, as a robustness check we limit the sample to the set of products that we predict might conceivably have been commercialized under any of the four commercialization modes. Following Rosenbaum & Rubin (1983) and Imbens (2000), we estimate a propensity score that each product will be commercialized under one commercialization mode rather than each of the other alternatives, and then use this to construct a matched sample of products using nearest-neighbor matching with replacement.

To be more specific, for each pair of commercialization modes (i.e., for the 10 commercialization-mode pairs generated from the set of four modes) we estimate using a probit specification the probability that the product will be commercialized by one mode rather than the other, based on the set of control variables that predate commercialization-mode choice – (a) product at least phase 2, (b) product at least phase 3, (c) # citations to primary patent (log), (d) product age (years) & (e) product age squared, (f) originator commercialization capabilities. We then select the set of products for which the propensity score is within the range of the propensity scores of the other mode (i.e., which lie on the common support) for all three alternative commercialization modes. Finally, we match each product developed under one commercialization mode to the product with the closest propensity score that was developed under the other commercialization modes. We allow a product commercialized under one mode to be used as a match to more than one product commercialized under another mode so the total number of observations used in matched regression may be greater than the number of products in the sample. In the matched regression, we cluster the standard errors by product.

Hazard-rate model. A possible limitation of the baseline probit specification is that it does not account for censoring of observations (i.e., that the reason we did not observe product approval is because

too short a time has elapsed). Hence, as an alternative we also estimate the empirical model using a Cox proportional hazard-rate specification. The Cox specification estimates the average "hazard" (or likelihood) of approval across the entire lifespan using information from the full set of observations in the dataset, and then shows the comparison relative to the average – or baseline – hazard profile. It then examines the extent to which differences in the explanatory variables are correlated with differences relative to the baseline hazard. An advantage of this specification is that observations are compared against the baseline only for the period in which they were observed, and hence it accounts for right censoring of the product outcome. This is particularly useful in this case because the average time from discovery to approval is at least 10 years and can range up to 20 years, and many of the products in the dataset are younger than this. Another advantage of the Cox specification in this context is that it examines the relationship with the instantaneous "hazard" or likelihood of approval, which affects both the cumulative likelihood of approval and the time to approval, rather than just the cumulative likelihood. This is especially appropriate in this context since biotech and pharmaceutical firms are interested in both aspects.

4 Empirical Analysis

4.1 Descriptive statistics

Table 2 presents a series of tabulations that describe the set of products in our dataset. Panel A shows that the database contains 1370 product candidates, but because some are "indicated" for multiple therapeutic conditions (up to a maximum of 18), there is a total of 2340 product-indications. Because both commercialization mode and whether a product is approved for sale may vary by indication, we use the product-indication as our unit of analysis. Nevertheless, because both the choice of commercialization mode and the likelihood of approval for different indications of the same product are highly correlated, in our regression analysis we cluster by product. (We henceforth use the term "product" to refer to a product-indication unless otherwise specified.)

Panel A also tabulates the type of organization that discovered the product (biotech, pharmaceutical, or university). It indicates that although the large majority (80%) of products were discovered in-house at a biotech firm, a significant number come from other sources (including universities and pharmaceutical firms).

Panel B gives some statistics on the number of transfers observed for each product-indication in the dataset (before approval, termination, or the end of the observation period). Transfers include licensing the product, sale of the product, and sale of the firm. Panel B reveals that while some products are developed through to approval by one firm, many products were transferred once or multiple times, up to as many as 17 times. This means a number of organizations that might hold the product over its

lifespan, so we choose to focus our analysis on the commercialization mode taken by the first biotech firm that held exclusive rights to the product after it entered clinical trials. We choose this cut-off point because entering clinical trials requires a significant investment and hence indicates that the product must have shown sufficient promise in the lab (and preclinical testing in animals) to warrant the necessary investment. It is also the point at which development expertise becomes relevant, and so both the choice of commercialization mode – whether through straight licensing, co-development, or self-commercialization – and the extent of innovator's capabilities in commercialization become critically important.[18] This limits the dataset to one observation per product. It also eliminates 961 products from our dataset, either because the product never reached clinical trials or because no biotech firm held exclusive rights after that point.

Panel C shows that, of the remaining 1379 products, roughly a third each are sold, commercialized alone, or commercialized through one of the two contractual modes. Within those contractual modes, slightly fewer more are commercialized through a co-development arrangement (19%) than through a straight-licensing arrangement (14%).

Table 3 presents summary statistics for the variables used in the analysis, as well as pairwise correlations between those variables, with the full set of observations. The measure of technological innovativeness – the number of citations to the primary patent – is missing for about a quarter of the observations because we were unable to identify the primary patent. In those cases we replace the missing values with the mean value; in the regression we included an indicator for whether the value was missing (and imputed).

Table 4 reports the mean probability of product approval conditional on commercialization mode and the nature of the innovator's experience. We observe that the highest probability of approval occurs when an innovator without any commercialization experience enters a straight-licensing arrangement, while the lowest probability of approval (zero) occurs when the innovator an innovator without any commercialization experience enters a co-development arrangement.

4.2 Regression results

Table 5 presents the coefficients of the multivariate regressions. Column (1) includes just the variables that capture the commercialization mode. The omitted category is straight licensing. Column (2) includes just the variables that capture the innovator's commercialization experience in phase 2 or above. The omitted category is no experience. Column (3) shows both sets of variables and their interactions.

[18] As a robustness check we also replicated our analysis using higher cut-off points (e.g., entering phase 2 trials). The results are consistent, although the sample size is much smaller and not all the results are significant.

The omitted category is products that are commercialized through licensing by innovators with no commercialization experience. These regressions are estimated with a probit specification and we report the robust standard errors, clustered by product, in parentheses.

However, as discussed above, one concern is that the results are biased by an omitted variable. To address this we add a series of control variables in Column (4) that attempt to deal with any omitted variables. Another potential concern is that the sets of products that are commercialized under the different commercialization modes are significantly different from each other to the extent that simply controlling for omitted variables does not adequately account for variation between products. In Column (5) we show the results estimated with each observation matched to the nearest neighbor in each of the other options (plus controls).[19] Finally in column (6) we show the results estimated using a Cox proportional hazard-rate model (with propensity-score matching and controls).[20]

In order to interpret the results from non-linear regressions such as these, it is necessary to calculate how the predicted probability of product approval varies with the choice of mode and level of experience. We present the predicted probabilities graphically in Figure 2.

Panel A shows the predicted probability of product approval under each commercialization mode when the originating firm has no commercialization experience (of any type). Panel B shows the predicted probabilities under each commercialization mode when the originating firm has commercialization experience by whether the innovator has co-development experience vs. straight-licensing experience only. Panel C shows the predicted probability under each mode when the originating firm has commercialization experience by whether the innovator has self-commercialization experience vs. straight-licensing experience (from left to right, respectively). In all three cases the probabilities are calculated from the results of the regression in Column (4) – that is, the probit model with controls. The bars show the 90% confidence intervals.

Panel A shows that when the originating firm has no commercialization experience, the product is significantly more likely to be approved if it licenses the product than if it enters a co-development arrangement or commercializes the product alone. The difference in the probability of approval between the latter two modes is not significant, however. From Panel B we observe that having co-development instead of straight-licensing experience is associated with a higher probability of approval when a firm

[19] The sample for the matching analysis includes only the 1326 observations that lie on the common support for all four commercialization modes. The much higher number observations in the analysis reflects that a number of observations appear multiple times as nearest neighbor to another observation. Since the standard errors are clustered by product this should not overstate the significance of the coefficients.

[20] In the Cox model, the analysis time is product age; hence we do not include product age and product age squared as covariates in these regressions.

engages in co-development, although the nature of the experience makes no difference under the other modes. Similarly Panel C reveals that the predicted probability of product approval under a co-development mode is significantly higher (just, at the 10% level) when the originating firm has self-commercialization experience rather than straight-licensing experience, but not under any other commercialization mode. In economic terms, when the originating firm has no experience the marginal effect of using a licensing mode versus co-development or self-commercialization is 13% and 12% respectively. Meanwhile the marginal effect on the probability of product approval of having co-development experience vs. straight licensing experience for a firm that pursues a co-development mode is 8% while the effect of having self-commercialization experience vs. straight licensing experience is 2%.

These results quantify the short-run costs and long-run benefits of choosing either joint commercialization or self-commercialization relative to straight licensing in the context of commercialization of pharmaceutical products. They suggest that the innovator incurs a significant short-run penalty in the likelihood that its product will be commercialized when it chooses one of the commercialization modes that allows it to participate in the commercialization process. However, the results also show that firms with both co-development and self-commercialization experience are more likely for their products to be commercialized relative to firms that merely have straight-licensing experience. Specifically the originating firm that enters into a co-development arrangement does better in the commercialization process if it prior experience of either type, although not necessarily if it commercializes alone. Nevertheless, because we are unable to control for all the factors that determine choice of commercialization mode, our empirical analysis does not allow us to establish that choosing a more integrated commercialization mode *causes* higher performance over the long term.

5 Discussion & Conclusion

This paper extends the Teece (1986) framework for analyzing an innovator's commercialization strategy to the situation in which the firm innovates repeatedly and is able to develop its own specialized commercialization capabilities through learning from its commercialization experience. We argue that under this situation the innovator may be better off commercializing alone even when it is at a disadvantage relative to the incumbents in the complementary assets. In addition, we argue that an intermediate strategy, joint commercialization, may be superior to either of the traditional commercialization modes under certain circumstances. Nevertheless, the innovator may incur a short-run penalty from engaging in either joint commercialization or self-commercialization, and therefore these strategies will only be worthwhile if the long-run benefits outweigh the short-run opportunity costs.

More concretely, our study makes two contributions to the technology commercialization strategy literature. First, most of the prior work in this domain, whether focused on value capture (Teece, 1986) or on the relationship between the business environment and commercialization strategy (Gans & Stern, 2003), concentrates on the development of a single innovation. However, while entrepreneurs certainly focus on such considerations, they also care about broader issues relating to organizational development. As a result, we believe that our shift in perspective to the organizational level is a useful contribution.

Our second contribution is to bring a more dynamic perspective to the literature. Most of the prior work adopts a static perspective,[21] and is silent on the issue of how firms develop specialized commercialization capabilities. This is a critical gap in the literature, especially given the importance of specialized commercialization capabilities in value appropriation from innovation (Teece, 1986).

We suggest three potential avenues for future work that would deepen our understanding of how, when and why entrepreneurial firms develop specialized complementary assets. First, it would be valuable to examine how the joint-commercialization arrangement that we study compares to other contractual and non-contractual means by which entrepreneurs seek to develop specialized complementary assets. While we compare joint commercialization and self-commercialization to straight licensing in our empirical analysis, there may be other organizational arrangements for developing downstream commercialization capabilities that may be superior to one or both of these under certain circumstances.

Second, while we examined the benefits of joint- and self-commercialization experience in the product development process, it would be interesting to empirically study how organizations accumulate commercialization-mode experience, along the lines of Aggarwal & Hsu's (2009) study of the persistence in a firm's choice of governance modes. An understanding of such heterogeneity across a broader spectrum of commercialization modes would help answer a variety of "why" questions related to the organizational performance of innovators. In addition, such studies could help us better understand the boundary conditions within which joint-commercialization alliances are beneficial, thereby allowing us to understand why not *all* startups engage in such arrangements.

A final avenue for future work relates to a broader research agenda of how technology commercialization strategy evolves. In the focal study, the entrepreneurial firm temporarily cooperates with the incumbent, but over the longer term evolves into a position in which it may compete with the same incumbent. By contrast, Marx et al. (2013) examine a technology commercialization strategy that evolves in the opposite direction, namely the entrepreneurial firm initially competes with incumbents in

[21] Gans (2011) and Marx et al. (2013), discussed above, are exceptions

the product market, followed by a switch to cooperation. In the latter case, the main rationale is to validate the technical and/or commercial potential of a disruptive innovation via product-market entry, and after having done so, switching to more efficient cooperative arrangement. It would be interesting to contrast the motivations for these dynamic commercialization strategies (developing specialized complementary assets and product validation, respectively) with other possible rationales. In particular, while these strategies may be driven by pre-specified goals, other new ventures may face dimensions of uncertainty which may require completely different commercialization strategies altogether.

While much more research is necessary to understand the various motivations and outcomes of technology commercialization strategy, this study suggests that participating in the commercialization process, either through joint commercialization with an industry incumbent or by commercializing alone, is an important means by which innovating firms improve their ability to capture value from innovation.

Table 1: Technology commercialization mode characteristics

	License to incumbent	Joint commercialization with incumbent	Self-commercialization
Likelihood of commercialization success	Highest due to partner's commercialization capabilities (assuming incentive alignment)	Lower relative to straight licensing due to "transaction costs" but higher than self-commercialization due to access to the partner's capabilities	Lowest (initially) due to inferior capabilities
Organizational learning	None. Innovator remains in same position in commercializing subsequent innovations	Yes, due to participating in commercialization activities alongside the incumbent	Yes, from own experience, although lower than under joint commercialization because no knowledge transfer from incumbent
Compensation structure	Typically licensing structure: innovator receives fixed &/or variable payments, but without cost outlays	Typically partnership structure: each side captures share of revenues and bear share of costs	Full ownership structure: innovator captures all revenues and incurs full development costs
Indirect costs	Standard contractual governance costs. No costs of learning or governing learning alliance.	Standard contractual governance costs plus cost of governing learning alliance of learning.	Learning costs

Figure 1: Innovator's commercialization strategy decision tree

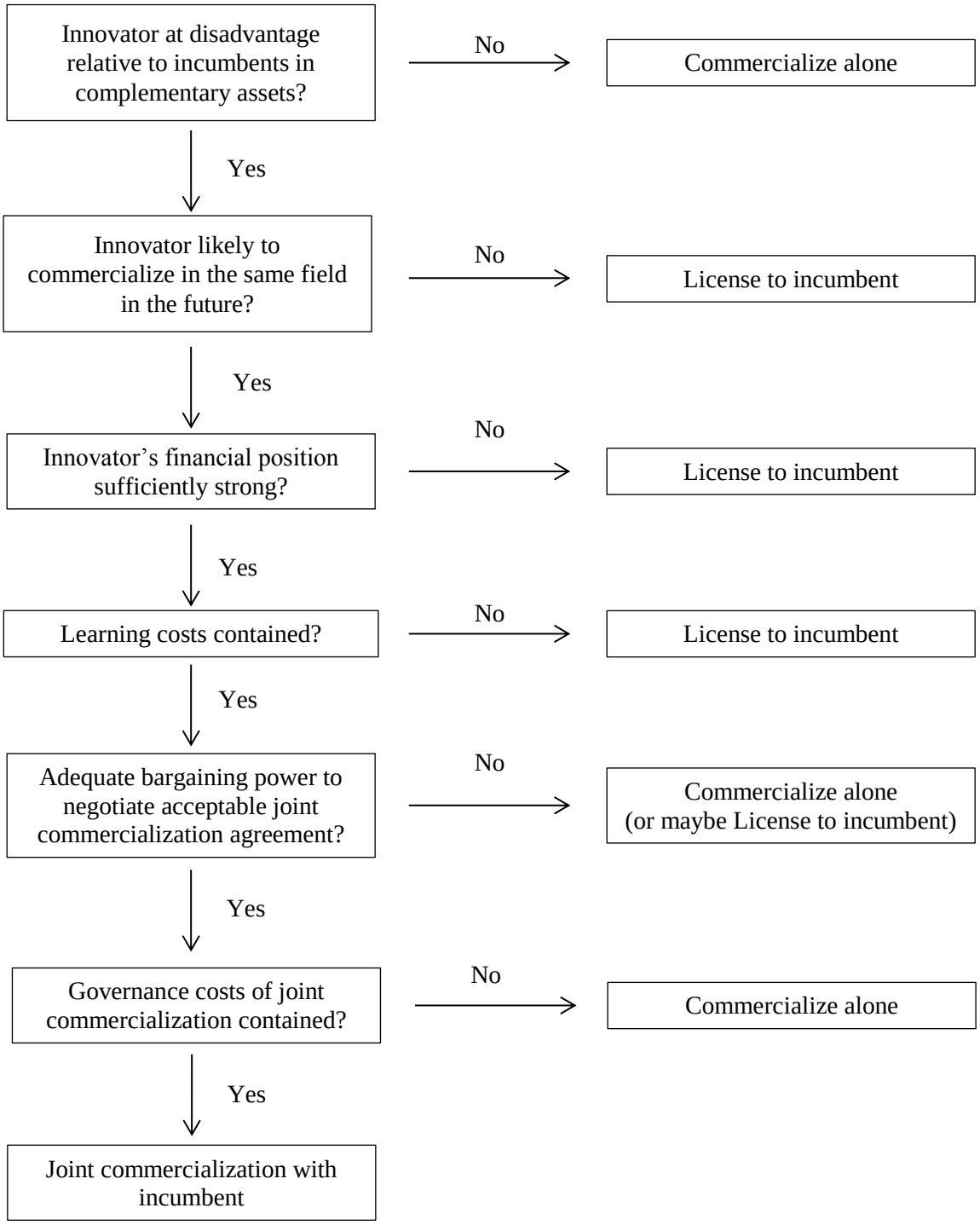


Table 2: Tabulations of product commercialization modes & outcomes

Panel A: Originating firm type

	Products		Product-indications	
Originator type	N	%	N	%
Biotech	1,091	79.64	1,811	77.39
University	151	11.02	296	12.65
Pharma	123	8.98	226	9.66
Other	5	0.37	7	0.3
Total	1,370	100	2,340	100

Panel B: Product transfers

	N	Min	mean	max
Product ultimately approved?				
no	2080	0	1.65	17
yes	260	0	1.72	12
Total	2,340	0	2	17

Panel C: Commercialization mode (by first biotech firm with rights in clinic)

Commercialization mode	Total	%
straight licensing	193	14.0%
co-development	272	19.7%
self-commercialization	450	32.6%
sale	464	33.6%
Total	1,379	

Table 3: Summary statistics and pairwise correlation matrix of variables

		(A)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(A)	Product approved in month	1.00																
(1)	Mode: straight licensing	0.11	1.00															
(2)	Mode: co-development	0.09	-0.20	1.00														
(3)	Mode: self-commercialization	-0.05	-0.29	-0.35	1.00													
(4)	Mode: sale	-0.11	-0.28	-0.35	-0.50	1.00												
(5)	Any commercialization experience	0.04	0.17	0.28	-0.16	-0.20	1.00											
(6)	Co-development experience	0.08	-0.13	0.35	0.09	-0.29	0.49	1.00										
(7)	Self-commercialization experience	0.02	0.13	0.22	-0.11	-0.18	0.93	0.45	1.00									
(8)	Product at least phase 2 at transfer	0.15	0.10	0.18	0.25	-0.49	0.25	0.20	0.24	1.00								
(9)	Product at least phase 3 at transfer	0.35	0.07	0.15	0.05	-0.23	0.17	0.15	0.15	0.48	1.00							
(10)	Citations to priority patent (log)	0.08	0.11	0.03	-0.03	-0.07	0.06	0.10	0.02	0.00	0.04	1.00						
(11)	Citations to priority patent missing	-0.17	-0.09	-0.17	-0.08	0.29	-0.15	-0.14	-0.12	-0.25	-0.18	0.06	1.00					
(12)	Originator product age (years)	0.08	0.12	0.19	0.41	-0.67	0.19	0.21	0.19	0.51	0.28	0.16	-0.33	1.00				
(13)	Originator product age squared	0.06	0.04	0.10	0.26	-0.38	0.08	0.08	0.09	0.35	0.23	0.13	-0.26	0.90	1.00			
(14)	Originator commercialization capabilities	0.07	0.00	-0.05	0.06	-0.02	0.29	0.21	0.29	-0.01	0.03	0.06	-0.04	0.03	0.01	1.00		
(15)	Developer commercialization capabilities	0.13	0.17	0.25	0.02	-0.35	0.29	0.27	0.25	0.17	0.15	0.14	-0.15	0.19	0.05	0.17	1.00	
(16)	Prior alliance between two parties	0.04	-0.04	0.01	0.24	-0.22	0.17	0.31	0.15	0.18	0.04	0.14	-0.05	0.22	0.10	0.21	0.28	1.00
	Observations	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379	1379
	Mean	0.06	0.14	0.20	0.34	0.33	0.63	0.29	0.59	0.38	0.13	3.23	0.41	8.45	137.67	0.14	1.54	0.15
	Standard Deviation	0.24	0.35	0.40	0.47	0.47	0.48	0.45	0.49	0.49	0.33	0.97	0.49	8.14	233.83	0.70	2.77	0.36
	Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.30	-0.30	0
	Maximum	1	1	1	1	1	1	1	1	1	1	6.394	1	50.67	2567	4.89	15.87	1

Note: This table presents the summary statistics and pairwise correlations of the variables used in the analysis for the full set of observations. When information on the primary patent is missing, the value of citations to the primary patent was replaced with the mean value and the indicator of whether the value was missing was set to one.

Table 4: Mean probability of approval by commercialization mode and experience type

Commercialization mode	All	No phase 2+ experience	Phase 2+ experience	Licensing experience	Co-development experience	Self-comm. experience	N
Mode: straight licensing	0.124	0.212	0.106	0.120	0.074	0.103	193
	(0.024)	(0.072)	(0.024)	(0.027)	(0.051)	(0.025)	
Mode: co-development	0.103	0.000	0.114	0.088	0.152	0.113	272
	(0.018)	0.000	(0.020)	(0.025)	(0.028)	(0.021)	
Mode: self-commercialization	0.022	0.022	0.023	0.015	0.022	0.019	450
	(0.007)	(0.010)	(0.010)	(0.010)	(0.022)	(0.009)	
Mode: sale	0.041	0.062	0.031	0.022	0.039	0.032	464
	(0.009)	(0.020)	(0.010)	(0.010)	(0.015)	(0.010)	
Total	0.059	0.049	0.063	0.055	0.084	0.060	1379
	(0.006)	(0.010)	(0.008)	(0.009)	(0.014)	(0.008)	
Total	1379	432	947	632	416	895	

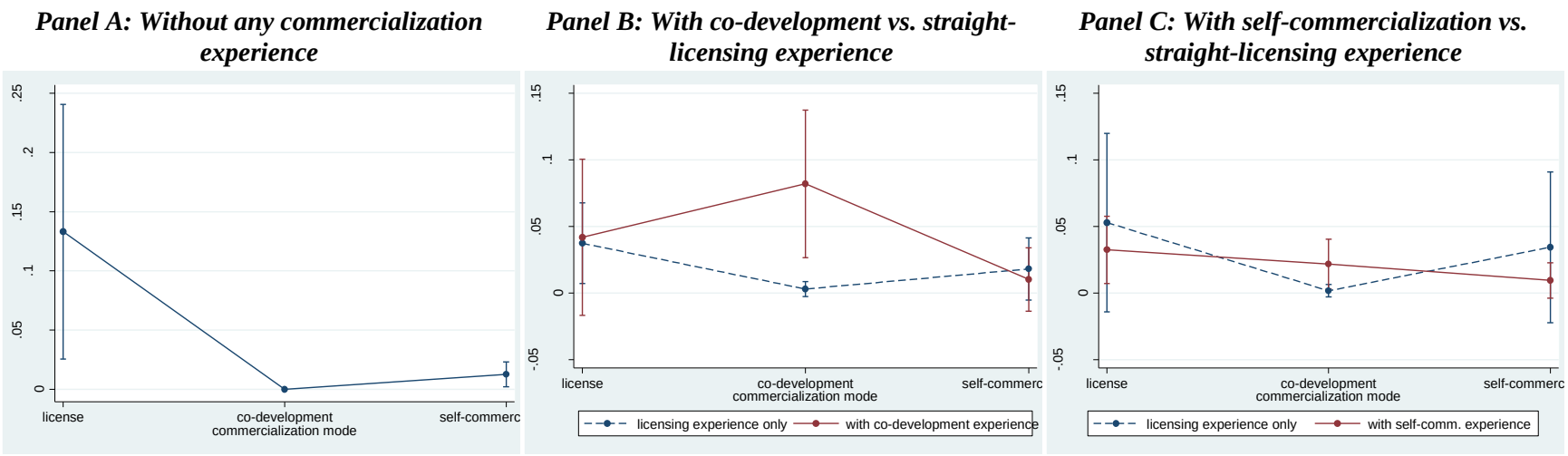
Note: This table presents the mean probabilities of product approval by commercialization modes and level/nature of experience. Standard errors are in parentheses.

Table 5: Regressions of product approval on commercialization mode & experience

	(1) Probit	(2) Probit	(3) Probit	(4) Probit	(5) Probit with PSM	(6) Cox with PSM
Mode: co-development	-0.111		-4.323***	-4.415***	-4.306***	-18.980***
	(0.194)		(0.389)	(0.301)	(0.545)	(0.944)
Mode: self-commercialization	-0.856***		-1.216***	-1.126***	-0.399	-3.313***
	(0.199)		(0.422)	(0.395)	(0.524)	(0.779)
Mode: sale	-0.586***		-0.738*	-0.892**	-0.449	-0.644
	(0.193)		(0.421)	(0.363)	(0.539)	(0.947)
Any commercialization experience		0.316	-0.312	-0.567	-0.720	-1.098
		(0.287)	(0.469)	(0.444)	(0.671)	(0.889)
Co-development experience		0.299**	-0.220	-0.098	-0.326	0.964
		(0.149)	(0.397)	(0.427)	(0.392)	(0.663)
Self-commercialization experience		-0.359	-0.115	-0.483	0.091	-0.728
		(0.257)	(0.315)	(0.407)	(0.591)	(0.852)
Mode: co-development			3.653***	3.048***	3.121***	17.735***
X Any comm. experience			(0.693)	(0.704)	(0.859)	(0.000)
Mode: co-development			0.976**	0.986*	1.364**	0.234
X Co-development experience			(0.494)	(0.548)	(0.568)	(0.979)
Mode: co-development			0.109	0.763	0.503	0.460
X Self-comm. experience			(0.533)	(0.607)	(0.706)	(1.083)
Mode: self-commercialization X			1.003	0.932	1.463	3.038**
Any commercialization experience			(0.769)	(0.696)	(0.966)	(1.202)
Mode: self-commercialization X			0.184	-0.184	0.742	-0.516
Co-development experience			(0.650)	(0.750)	(0.868)	(1.287)
Mode: self-commercialization X			-0.630	-0.228	-1.789**	-1.353
Self-commercialization experience			(0.675)	(0.631)	(0.856)	(1.207)
Interaction effects on Model: sale	N	N	Y	Y	Y	Y
Control variables	N	N	N	Y	Y	Y
Constant	-1.154***	-1.658***	-0.799**	-0.773**	-1.086*	
	(0.145)	(0.131)	(0.386)	(0.377)	(0.618)	
Observations	1,379	1,379	1,379	1,379	6,252	6,252
# product-indication-instances	1,379	1,379	1,379	1,379	1,326	1,326
# products	840	840	840	840	804	804

Note: This table shows the set of regressions of product approval on commercialization mode and commercialization experience. The dependent variable is an indicator of whether a product was approved in a given month. Column (1) includes just the variables that capture the commercialization mode. The omitted category is straight licensing. Column (2) includes just the variables that capture the innovator's commercialization experience in phase 2 or above. The omitted category is no experience. Column (3) shows both sets of variables and their interactions. The omitted category is products that are commercialized through licensing by innovators with no commercialization experience. The sale mode interactions are hidden. We include the following control variables in regressions (4)-(6): (a) product at least phase 2, (b) product at least phase 3, (c) # citations to primary patent (log), (d) product age (years) & (e) product age squared, (f) originator commercialization capabilities, (g) developer commercialization capabilities, and (h) prior alliance between two parties When information on the primary patent is missing, the value of citations to the primary patent is replaced with the mean value and the indicator of whether the value was missing was set to one. The results were estimated using a probit specification (columns 1-5) and a Cox proportional hazard-rate specification (column 6) respectively. In the Cox specification, analysis time is product age; hence product age and product age squared are not included as covariates. In columns 5 & 6 the sample is constructed used nearest-neighbor matching with replacement. We report the coefficients with robust standard errors, clustered by product, in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Figure 2: Predicted probability of product approval by co-development versus straight-licensing experience



Note: This figure shows the predicted probabilities of product approval by commercialization mode and level/type of experience. Panel A shows the predicted probability of product approval under each commercialization mode when the originating firm has no commercialization experience (of any type). Panel B shows the predicted probabilities under each commercialization mode when the originating firm has commercialization experience by whether the innovator has co-development experience vs. straight-licensing experience only. Panel C shows the predicted probability under each mode when the originating firm has commercialization experience by whether the innovator has self-commercialization experience vs. straight-licensing experience. In all three cases the probabilities are calculated from the results of the regression in Column (4) – that is, the probit model with controls. The bars show the 90% confidence intervals.

6 References

Aggarwal, V.A., Hsu, D.H., 2009. Modes of cooperative R&D commercialization by start-ups. Strategic Management Journal, 30, 835-864.

Aghion, P., Tirole, J., 1994. The Management of Innovation. The Quarterly Journal of Economics, 109, 1185-1209.

Anand, B.N., Khanna, T., 2000. Do Firms Learn to Create Value? The Case of Alliances. Strategic Management Journal, 21, 295-315.

Arora, A., Ceccagnoli, M., 2006. Patent Protection, Complementary Assets, and Firms' Incentives for Technology Licensing. MANAGEMENT SCIENCE, 52, 293-308.

Arora, A., Merges, R.P., 2004. Specialized supply firms, property rights and firm boundaries. Industrial & Corporate Change, 13, 451-475.

Barney, J.B., 1986. Types of Competition and the Theory of Strategy: Toward an Integrative Framework. Academy of Management Review, 11, 791-800.

Baum, J.A.C., Calabrese, T., Silverman, B.S., 2000. Don't go it alone: alliance network composition and startups' performance in Canadian biotechnology. Strategic Management Journal, 21, 267-294.

Chesbrough, H., Birkinshaw, J., Teubal, M., 2006. Introduction to the research policy 20th anniversary special issue of the publication of. Research Policy, 35, 1091-1099.

Cohen, W., Levinthal, D., 1990. Absorptive capacity: A new perspective on learning and innovation. Administrative Science Quarterly.

Dierickx, I., Cool, K., 1989. Asset stock accumulation and sustainable competitive advantage. MANAGEMENT SCIENCE, 35, 1504-1511.

Doz, Y.L., 1996. The evolution of cooperation in strategic alliances: Initial conditions or learning processes? Strategic Management Journal, 17, 55-83.

Gans, J.S., 2011. Negotiating for the Market, The Selected Works of Joshua S Gans.

Gans, J.S., Hsu, D.H., Stern, S., 2002. When Does Start-Up Innovation Spur the Gale of Creative Destruction? RAND Journal of Economics, 33, 571.

Gans, J.S., Stern, S., 2003. The product market and the market for "ideas": commercialization strategies for technology entrepreneurs. Research Policy, 32, 333.

Gomes-Casseres, B., Hagedoorn, J., Jaffe, A.B., 2006. Do alliances promote knowledge flows? Journal of Financial Economics, 80, 5-33.

Grant, R.M., Baden-Fuller, C., 2004. A Knowledge Accessing Theory of Strategic Alliances. Journal of Management Studies, 41, 61-84.

Hall, B.H., Jaffe, A., Trajtenberg, M., 2005. Market Value and Patent Citations. The RAND Journal of Economics, 36, 16-38.

Hall, B.H., Jaffe, A.B., Trajtenberg, M., 2001. The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools, NBER Working Paper.

Hamel, G., 1991. Competition for Competence and Inter-Partner Learning Within International Strategic Alliances. Strategic Management Journal, 12, 83-103.

Holmstrom, B., Milgrom, P., 1991. Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design. Journal of Law, Economics and Organization, 7, 24.

Imbens, G.W., 2000. The role of the propensity score in estimating dose-response functions. Biometrika, 87, 706-710.

Inkpen, A.C., Beamish, P.W., 1997. Knowledge, Bargaining Power, and the Instability of International Joint Ventures. The Academy of Management Review, 22, 177-202.

Jacobides, M.G., Knudsen, T., Augier, M., 2006. Benefiting from innovation: Value creation, value appropriation and the role of industry architectures. Research Policy, 35, 1200-1221.

Kale, P., Singh, H., Perlmutter, H., 2000. Learning and protection of proprietary assets in strategic alliances: building relational capital. Strategic Management Journal, 21, 217-237.

Khanna, T., Gulati, R., Nohria, N., 1998. The dynamics of learning alliances: competition, cooperation, and relative scope. Strategic Management Journal, 19, 193-210.

Kogut, B., 1988. Joint Ventures: Theoretical and Empirical Perspectives. Strategic Management Journal, 9, 319-332.

Lane, P.J., Lubatkin, M., 1998. Relative absorptive capacity and interorganizational learning. Strategic Management Journal, 19, 461-477.

Lavie, D., Lechner, C., Singh, H., 2007. The Performance Implications of Timing of Entry and Involvement in Multi-Partner Alliances. Academy of Management Journal, 50, 578-604.

Marx, M., Gans, J.S., Hsu, D.H., 2013. Dynamic Commercialization Strategies for Disruptive Technologies: Evidence from the Speech Recognition Industry. Unpublished paper.

Mowery, D.C., Oxley, J.E., Silverman, B., 1996. Strategic alliances and interfirm knowledge transfer. Strategic Management Journal, 17, 77–91

Nicholson, S., Danzon, P.M., McCullough, J., 2005. Biotech-Pharmaceutical Alliances as a Signal of Asset and Firm Quality. Journal of Business, 78, 1433-1464.

Oxley, J.E., Sampson, R.C., 2004. The scope and governance of international R&D alliances. Strategic Management Journal, 25, 723-749.

Parkhe, A., 1993. Strategic Alliance Structuring: A Game Theoretic and Transaction Cost Examination of Interfirm Cooperation. Academy of Management Journal, 36, 794-829.

Pisano, G.P., 1990. The R&D Boundaries of the Firm: An Empirical Analysis. Administrative Science Quarterly, 35, 153-176.

Pisano, G.P., Teece, D.J., 2007. How to capture value from innovation: Shaping intellectual property and industry architecture. California Management Review, 50, 278-296.

Reuer, J.J., Zollo, M., Singh, H., 2002. Post-Formation Dynamics In Strategic Alliances. Strategic Management Journal, 23, 135.

Rosenbaum, P.R., Rubin, D.B., 1983. The central role of the propensity score in observational studies for causal effects. Biometrika, 70, 41-55.

Rothaermel, F.T., 2001. Incumbent's advantage through exploiting complementary assets via interfirm cooperation. Strategic Management Journal, 22, 687-699.

Salanie, B., 1997. The Economics of Contracts: A Primer. Massachusetts Institute of Technology: Cambridge, MA.

Shane, S., 2000. Prior Knowledge and the Discovery of Entrepreneurial Opportunities. Organization Science, 11, 448-469.

Stuart, T.E., 2000. Interorganizational alliances and the performance of firms: A study of growth and innovation rates in a high-technology industry. Strategic Management Journal, 21, 791-811.

Szulanski, G., 1996. Exploring Internal Stickiness: Impediments to the Transfer of Best Practice Within the Firm. Strategic Management Journal, 17, 27-43.

Teece, D.J., 1980. Economies of scope and the scope of the enterprise. Journal of Economic Behavior & Organization, 1, 223-247.

Teece, D.J., 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. Research Policy, 15, 285-305.

Tripsas, M., 1997. Unraveling the process of creative destruction: Complementary assets and incumbent survival in the typesetter industry. Strategic Management Journal, 18, 119-142.

Wakeman, S., 2007. Contracting and Intellectual Property Issues in Biotech Commercialization Strategy, Business Administration. University of California at Berkeley.

Williamson, O.E., 1975. Markets and Hierarchies: Analysis and Antitrust Implications. Free Press: New York, NY.

Williamson, O.E., 1985. The Economic Institutions of Capitalism. Free Press: New York, NY.

Williamson, O.E., 1996. The Mechanisms of Governance. Oxford University Press: New York, NY.

Winter, S.G., 2003. Understanding dynamic capabilities. Strategic Management Journal, 24, 991-995.

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